Outdoor Facts

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PORTABLE COMPUTER SYSTEM FOR FIELD PROCESSING BIOTELEMETRY TRIANGULATION DATA

Collection of animal movement data using biotelemetry triangulation systems can generate large volumes of data. Typically, field workers use hand-written data forms to record azimuths from receiver locations to the animal with a later transfer to a computer-readable format for complete analysis. Data quality is seldom evaluated during this process because of the complexity of calculations. Hence, needed corrective measures or adjustments in data collection procedures are seldom identified until after the tracking session is completed. In this Leaflet we describe use of a portable computer to record, evaluate, and store telemetry data as they are collected in the field. The system was developed for a study of summer habitat use by mule deer *(Odocoileus hemionus)* in northwestern Colorado conducted cooperatively by Los Alamos National Laboratory, Colorado Division of Wildlife, and Colorado State University. With this system, animal locations can be calculated and graphically and numerically displayed immediately. Upon completion of the tracking session, data are off-loaded from the portable computer to a main-frame computer via telephone for complete processing.

METHODS

The triangulation system used in this study employed 8 permanent 10.5-m tall antenna towers arranged in equilateral triangles approximately 2 km on a side. Simultaneous azimuths to a radio-collared deer were taken from 3 towers and communicated by 2-way radio to the person at one of the towers who was operating the portable computer. A second person recorded the data on standard computer forms in the event of a computer failure.

A Radio Shack TRS-80 Model 100 portable computer, with 32k bytes of memory, processes and stores triangulation data as they are collected. Four AA 1.5-volt dry cells provide 20 hours of processing time with 8 to 20 days of memory retention, depending on the amount of data stored, after the dry cells are depleted. The unit measures 21 × 30 × 5 cm and weighs ≃ 2 kg.

The computer is programmed in BASIC with approximately 200 lines of code utilizing 3k bytes of memory (Appendix). Upon execution, this code requests the user enter the azimuth standard deviation for use with the maximum likelihood (ML) estimator of Lenth (1981) used in the program to calculate the 95% confidence area of a location estimate. Next, the identities of the 3 towers to be used during the data collection session are requested. The Universal Transverse Mercator (UTM) coordinates (U.S. Army 1973) of the 3 to 8 towers on the study area are stored in a previously prepared file on the portable computer. After these preliminary steps, the program enters a data collection and processing loop. The user is requested to enter an animal identification code (usually the radio frequency) and the azimuths from each of the 3 towers. These values plus their associated tower identity and the current date and time obtained from the computer's internal clock are written to a file on the random access memory (RAM). Thus, the user is not required to provide the date or time of the location.

After the values are stored, graphical and numerical outputs are provided on the 239 × 63-pixel display screen to allow evaluation of the location (Fig. 1). Towers are plotted as 3 × 3-pixel squares with azimuths shown as lines radiating from them. Hence, the user can visually assess closeness of the 3 intersections that make up the location estimate. For example, if Tower 2 is reading an off-axis null from the antenna system, this azimuth will not properly intersect with the others (Fig. 2) and corrective measures can be taken. Analytical results are shown along the left side of the display, including the estimate of the UTM coordinates of the location and the area of the 95% confidence ellipse.

After completing the tracking session, the data can be permanently stored on a cassette tape unit compatible with the portable computer. However, a major advantage of this system is that the data can also be transferred by telephone to a mainframe computer for complete processing. The TRS-80 Model 100 computer has a built-in 300-baud modem and a terminal emulation program which allow convenient off-loading of the data.

DISCUSSION

The system described provides 2 advantages over conventional techniques. First, people collecting triangulation data can verify its quality while still in the field and immediately apply necessary corrective measures. In addition, if an animal moves beyond the area where acceptable locations can be taken, e.g., the confidence ellipse area is greater than a specified value, a different animal can be monitored or observers can move to a different set of towers. Thus, quality of the data is improved while the level of effort is the same as with conventional techniques.

A second advantage of the system is that human intervention in data recording is only necessary once — when the user enters azimuths into the portable computer. This reduces data handling over conventional methods and minimizes the potential for recording errors.

The 32k-byte memory of the portable computer used in this study can store >400 locations before the RAM is full. However, locations can be saved in the field with a battery operated cassette tape recorder. The computer can also be used to perform more complicated analyses, such as home range estimates or rate of movement, and hard copy of the output can be obtained with the addition of a printer. However, we believe a thorough analysis of triangulation data would generally require a larger computer for which more sophisticated statistical packages are available. The TRS-80 Model 100 does not have a FORTRAN compiler, so most available biotelemetry software would be compatible only if the codes were first translated to BASIC.

The TRS-80 Model 100 with 32k memory along with a portable cassette tape unit and associated cables costs approximately $1000. Similar portable computers are available from other manufacturers at comparable costs. Advantages of a portable computer easily justify the expenditure, especially when the high costs of telemetry equipment and manpower to perform the tracking are considered.

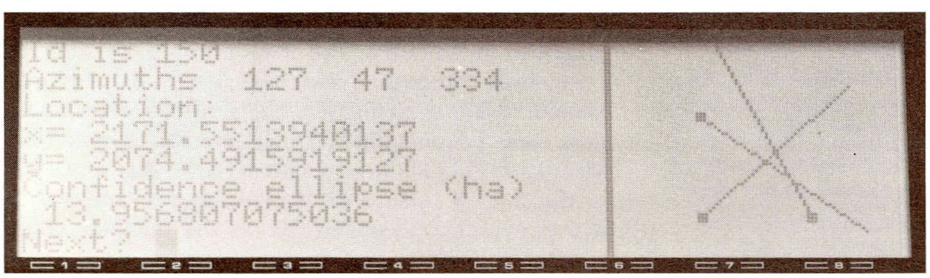

Fig. 1. Screen of the TRS-80 Model 100 portable computer with a set of triangulation azimuths illustrating a good location estimate.

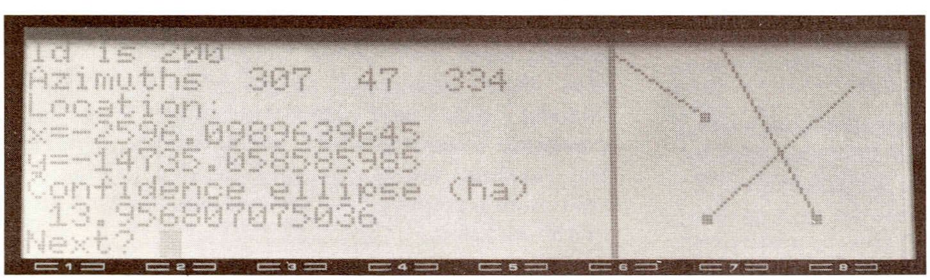

Fig. 2. Screen of the TRS-80 Model 100 portable computer displaying a set of triangulation azimuths where one observer has read the backside of the null-peak antenna.

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APPENDIX — Listing of the BASIC code for TRS-80 Model 100 portable computer for a 3- to 8-tower system using 3 towers simultaneously for triangulation.

```
10 DEFINT I-N
20 DIM AZ(3),UTM(2,8),IT(3),A(2,2),B(2)
30 PI=ATN(1.)*4.
40 INPUT "Azimuth Standard Deviation";CP
44 'Convert azimuth standard deviation to k
   appa
45 CP=EXP(CP^2*(-0.5)*PI/180.)
46 CP=1./(2.*(1.-CP)+(1.-CP)^2*(.48794-.829
   05*CP-1.3915*CP^2)/CP)
50 INPUT "Tower numbers";IT(1),IT(2),IT(3)
60 OPEN "ram:towers.do" FOR INPUT AS 1
70 FOR I=1 TO 8
80 INPUT #1,UTM(1,I),UTM(2,I)
90 NEXT I
100 CLOSE 1
111 XX=UTM(1,IT(1))
112 XN=XX
113 YX=UTM(2,IT(1))
114 YN=YX
115 FOR I=2 TO 3
116 IF XX < UTM(1,IT(I)) THEN XX=UTM(1,IT(I)
    )
117 IF XN > UTM(1,IT(I)) THEN XN=UTM(1,IT(I)
    )
118 IF YX < UTM(2,IT(I)) THEN YX=UTM(2,IT(I)
    )
119 IF YN > UTM(2,IT(I)) THEN YN=UTM(2,IT(I)
    )
121 NEXT I
130 XX=XX*1.3
131 XN=XN/1.3
132 YX=YX*1.3
133 YN=YN/1.3
134 YC=63/(YX-YN)
135 XC=63/(XX-XN)
136 IF YC > XC THEN YC=XC
137 IF XC > YC THEN XC=YC
200 CLS:OPEN "ram:azimth" FOR APPEND AS 1
210 ON ERROR GOTO 300
300 CLS:INPUT "Animal id & 3 azimuths";ID$,A
    Z(1),AZ(2),AZ(3)
330 IF ID$ = "end" THEN GOTO 3000
350 PRINT #1,USING "\           \ \         \ \
    \ # ### # ### # ###";DATE$;TIME$;ID$;
    IT(1);AZ(1);IT(2);AZ(2);IT(3);AZ(3)
360 GOSUB 500
370 GOTO 300
499 'Code to summarize azimuths and plot
500 CLS:PRINT "Id is ";ID$
501 PRINT "Azimuths ";AZ(1);AZ(2);AZ(3)
510 LINE (160,0)-(160,63)
511 LINE (159,0)-(159,63)
520 FOR I=1 TO 3
530 X=UTM(1,IT(I))
540 Y=UTM(2,IT(I))
550 GOSUB 1000
560 XE=X:YE=Y
570 R=XX-XN
580 IF YX-YN > R THEN R=YX-YN
585 AZ(I)=(90.-AZ(I))*(PI/180)
590 R=R-0.1*(XX-XN)
600 X=R*COS(AZ(I))+UTM(1,IT(I))
610 Y=R*SIN(AZ(I))+UTM(2,IT(I))
615 X=INT((X-XN)*XC)+175
616 Y=INT((YX-Y)*YC)
620 IF X < 160 THEN GOTO 590
630 IF Y < 0 THEN GOTO 590
640 IF X > 239 THEN GOTO 590
650 IF Y > 63 THEN GOTO 590
680 LINE(XE,YE)-(X,Y)
770 NEXT I
771 GOSUB 2000
772 PRINT "Location:"
773 PRINT "x=";XL
774 PRINT "y=";YL
776 PRINT "Confidence ellipse (ha)"
777 PRINT;EA
779 INPUT "Next";I
780 RETURN
1000 X=INT((X-XN)*XC+175)
1010 Y=INT((YX-Y)*YC)
1020 LINE(X-1,Y-1)-(X+1,Y+1),1,BF
1030 RETURN
2000 ON ERROR GOTO 779
2005 NI=0
2010 XL=(UTM(1,IT(1))+UTM(1,IT(2))+UTM(1,IT(3
     )))/3.
2020 YL=(UTM(2,IT(1))+UTM(2,IT(2))+UTM(2,IT(3
     )))/3.
2050 CV$="f"
2060 IN$="t"
2070 FOR I=1 TO 2
2080 B(I)=0.
2090 FOR J=1 TO 2
2100 A(I,J)=0.
2110 NEXT J
2120 NEXT I
2130 FOR I=1 TO 3
2140 SI=SIN(AZ(I))
2150 CI=COS(AZ(I))
2160 ZI=SI*UTM(1,IT(I))-CI*UTM(2,IT(I))
2170 IF IN$ = "f" THEN GOTO 2200
2180 SS=SI
2190 CS=CI
2195 GOTO 2230
2200 DI=SQR((XL-UTM(1,IT(I)))^2+(YL-UTM(2,IT(
     I)))^2)
2210 SS=(YL-UTM(2,IT(I)))/(DI^3)
2220 CS=(XL-UTM(1,IT(I)))/(DI^3)
2230 A(1,1)=A(1,1)+SI*SS
2240 A(2,2)=A(2,2)+CI*CS
2250 A(1,2)=A(1,2)-CI*SS
2260 A(2,1)=A(2,1)-SI*CS
2270 B(1)=B(1)+SS*ZI
2280 B(2)=B(2)-CS*ZI
2290 NEXT I
2300 YM=(A(1,1)*B(2)-A(2,1)*B(1))/(A(1,1)*A(2
     ,2)-A(2,1)*A(1,2))
2310 XM=(B(1)-A(1,2)*YM)/A(1,1)
2315 IN$="f"
2320 IF ABS(XM-XL)/XM < 0.00001 AND ABS(YM-YL
     )/YM < 0.00001 THEN CV$="t"
2330 XL=XM:YL=YM
2340 NI=NI+1
2350 IF CV$ = "f" AND NI < 20 THEN 2070
2360 'Convergence achieved - get vc mat
2365 ON ERROR GOTO 772
2367 V1=0.:V2=0.:V3=0.
2370 FOR I=1 TO 3
2380 SI=SIN(AZ(I))
2390 CI=COS(AZ(I))
2400 DI=SQR((XL-UTM(1,IT(I)))^2+(YL-UTM(2,IT(
     I)))^2)
2410 CS=(XL-UTM(1,IT(I)))/(DI^3)
2420 SS=(YL-UTM(2,IT(I)))/(DI^3)
2430 V1=V1+SI*SS
2440 V2=V2+CI*SS+SI*CS
2450 V3=V3+CI*CS
2460 NEXT I
2470 V2=V2*(-0.5)
2490 DI=1./((V1*V3-V2^2)*CP^2)
2500 EA=0.0001*PI*5.99*SQR(DI)
2505 ON ERROR GOTO 300
2510 RETURN
3000 CLS
3010 PRINT "Available memory allows";INT(FRE(
     0)/47)
3011 PRINT "locations to be stored before"
3012 PRINT "dumping file 'azimth.do' to tape"
3013 PRINT "or to another computer."
3030 END
```