DISTANGLE: A FORTRAN program to analyze and simulate spacing behavior of animals

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A FORTRAN IV program, DISTANGLE, was written to aid in analysis of orientation and spacing parameters among groups of animals within enclosures. The 700-statement program requires, as minimum input, individual animal identification, each animal's X and Y coordinates on a grid basis, and each animal's angle of orientation on a 360-deg basis. The program was designed to give versatility to the user. Input may be raw data from cards or simulated (random) observations generated by the program. The program calculates distances among group members and determines angle relationships among selected individuals. Frequency of nearest neighbor relationships, frequency of positioning of animals at locations within the enclosure, and movement distances are determined. DISTANGLE will determine the angles any two animals of a group would have to turn to be facing each other, regardless of their locations and/or orientations within the enclosure. The program permits analyses of spatial relationships among a maximum of 50 animals, either actual or simulated, per observation. Shape of enclosure can be either a square, a circle, or a triangle.

Spatial organization of plants and animals are important aspects of behavior and ecology, and interindividual distance is often used as an index of spatial arrangement (Beilharz & Mylrea, 1963; Clark & Evans, 1954; Goodall, 1952; Kilgour, 1969; Kummer, 1971; Syme, Syme, Waite, & Pearson, 1975). Orientation of individuals has been less frequently investigated, and studies of both distance and orientation relationships among animals are often descriptive rather than analytical.

McBride, James, and Shoffner (1963) measured both orientation and distance and calculated the partial regression of the angle of an animal on the angle of its nearest neighbor and on the distance separating the two animals. They concluded that subjects did not space and orient at random.

Even when working with a small number of animals per diagram or photograph, measurements of all combinations of distances and angles connecting individuals are extremely tedious, and the lines and angles involving such measurements become entangled. A FORTRAN IV program, DISTANGLE, was designed to increase the efficiency of data coding and analyses of distance and angle relationships of animals.

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Description of the Program. DISTANGLE is composed of several subroutines and approximately 700 FORTRAN statements. It is designed to give the user flexibility in the analysis of data pertaining to the spacing and orienting of animals. There are several options that can be called as needed. The user can control the number of animals per observation, up to a maximum of 50. The number of observations per analysis is not bounded. The user can either read actual animal observations input from cards, or random simulated observations can be generated.

The shape of the enclosure can be changed from a square to a triangle or circle with minor modifications of the program. Spacing and orientation relationships are defaulted to nearest neighbor animals. However, an animal (e.g., the most dominant individual) can be specified, and the angles and distances relationships of the other group members to the selected animal will be determined.

Several output options are available. Output form defaults to a line printer, but there is an option that allows the output of DISTANGLE to be punched onto cards that can later be analyzed using statistical programs. A scatter plot of each observation, distances among animals for each observation, mean distances among animals for Observations 1 through N, and a plot of positioning relationships of the observed, or a selected animal, to the other animals are options that can be called when desired. An angle and distance relationship table, which contains the pertinent information to the model presented by McBride, James, and Shoffner (1963), is printed for each observation.

Input Description. DISTANGLE requires only four input variables for each animal. The animal's numerical

code, the X and Y Cartesian grid coordinates, and an angle which defines the orientation of the animal on a 360-deg basis are required input variables.

Examples of Output. Output from DISTANGLE is generally in printed form. However, the distance and angle output information for the first nearest neighbor can be punched. Presented as an example is the result of 10 random simulated observations with five animals per observation (Tables 1-12). To conserve space, only the last observation is presented.

Hardware Requirements. This program currently runs on an IBM 370/168 under 05/360. DISTANGLE is compiled using the FORTRAN IV (G1) compiler.

Availability. A detailed description and/or copy of

Table 1
Coding for the Control Card and Description
of Variables and Options

The Control Card for This Analysis Was Read as Follows	Description of Variables and Options
N = 5	Number of animals per observation
NO = 10	Number of observations
10P1 = 0	Reference animal; 0 = nearest neighbor or a user-specified animal number
10P2 = 0	Location of each animal over all observa- tions (0) or not printed (1)
10P3 = 0	Matrix of nearest neighbor relations (0) or not printed (1)
10P4 = 0	Matrix of distances among animals for each observation (0) or not printed (1)
10P5 = 0	Average distance after each observation (0), after NO-TH observation (1), or not printed (2)
10P6 = 0	Type input; 0 = simulations or 1 = card input
10P7 = 0	Printed output (0) of punched output from angles (1)
10P8 = 0	Scatter plot of each observation (0) or not printed (1)
10P9 = 0	Printing of bubble; 0 = yes or 1 = no
10P10 = 0	Alpha and beta angles for all animals (0) or not printed (1)
10P11 = 0	Distance moved between observations (0) or not printed (1)

Table 2
Animal Identification, X and Y Coordinates, and the
MU Angle for Data in Observation Number 10
as Printed in Output

N	X	Y	MU
1	9.7	9.1	234
2	7.1	4.0	20
3	6.4	3.9	184
4	5.4	6.2	323
5	7.3	3.3	128

Table 3
Scatter Plots of Animals in Observation Number 10

SCATTER PLOT OF ANIMALS									

10 *								1 *	
*								*	
9 *								*	
*								*	
8 *								*	
*								*	
7 *					4			*	
*								*	
6 *								*	
*								*	
5 *							2	*	
*								*	
4 *						3	5	*	
*								*	
3 *								*	
*								*	
2 *								*	
*								*	
1	*****								
	1	2	3	4	5	6	7	8	9 10

Note—For location of animals, the X and Y coordinates are rounded to the next highest number, that is, for X = 9.7 and Y = 9.1, the plot is at Position 10, 10.

the program can be obtained by writing to H. B. Graves, 204 Animal Industries Building, The Pennsylvania State University, University Park, Pennsylvania 16802. There is no charge for the listings. Redistribution of the copyrighted program is prohibited.

Table 4
Distances Among Animals for Observation Number 10

	1	2	3	4	5
1	0.00				
2	5.72	0.00			
3	6.16	0.71	0.00		
4	5.19	2.78	2.51	0.00	
5	6.28	0.73	1.08	3.47	0.00

Table 5
Average Distances Among Animals
for Observations 1 through 10

	1	2	3	4	5
1	0.00				
2	4.86	0.00			
3	5.11	5.58	0.00		
4	5.21	5.25	4.40	0.00	
5	5.57	5.11	3.98	4.09	0.00

Table 6
Distance and Angular Relationships Between Each Animal and Its Nearest Neighbor or a Specified Individual

Animal Number	Nearest Neighbor or Specified Individual	Distance Between	Slope	Angle					Side*	Distance Moved Since Last Observation
				Theta	Omega	Phi	Alpha	Beta		
1	4	5.19	.67	33	125	54	21	70	2	6.33
2	3	.71	.14	8	20	160	168	176	2	5.35
3	2	.71	.14	8	176	4	176	168	2	1.08
4	3	2.51	-2.30	66	37	143	29	70	1	1.79
5	2	.73	-3.50	74	128	52	22	94	1	5.31
Totals		9.84			487	413	416	578		
Means		1.97			97	82	83	115		

*1 = opposite; 2 = same; 3 = on line

Table 7
Number of Times Animals Were Located at Different X, Y Positions Relative to the Reference Animal

	-14	-10	-5	0	5	10	14
14	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
-1	0	0	0	0	0	0	0
-2	0	0	0	0	0	0	0
-3	0	0	0	0	0	0	0
-4	0	0	0	0	0	0	0
-5	0	0	0	0	0	0	0
-6	0	0	0	0	0	0	0
-7	0	0	0	0	0	0	0
-8	0	0	0	0	0	0	0
-9	0	0	0	0	0	0	0
-10	0	0	0	0	0	0	0
-11	0	0	0	0	0	0	0
-12	0	0	0	0	0	0	0
-13	0	0	0	0	0	0	0
-14	0	0	0	0	0	0	0

Note—The arrow, →, in the matrix, represents the observed animal, which is located at the origin, or 0, 0 position. In addition to the locations listed, there were 0 animal positionings within 0.5 units of the origin, or 0, 0 position. The numbers in the matrix indicate the times animals were located at each position, relative to the observed (i.e., any given) animal.

Table 8
Number of Times Animals Were Nearest Neighbors

	1	2	3	4	5
1	0	3	3	2	2
2	4	0	3	3	0
3	2	2	0	3	3
4	2	2	2	0	4
5	1	2	3	4	0

Note—Read the table from left to right. In other words, Animal Number 1 had Animal Number 2 as his (or her) nearest neighbor three times, and each row sums to the number of observations.

Table 9
Overall Mean Distance and Angular Relationships Between Nearest Neighbors

		Grand Means
Distance Between Nearest Neighbors or to Specified Individual = 2.60		
Omega Angle	=	102
Phi Angle	=	77
Alpha Angle	=	88
Beta Angle	=	92
Total Sum of Individual Observations = 50		

Table 10
Total and Average Distances Moved by Individual Subjects

Animal Number	Total Distance Moved	Average Distance Moved Between Observations
1	45.25	5.03
2	51.94	5.77
3	41.53	4.61
4	32.01	3.56
5	49.63	5.51

Table 11
Alpha, Beta, and Side of Connecting Line Relations
(respectively) For All Animals For
Observation 10

	1	2	3	4	5
1	0	8	3	21	13
	0	42	127	70	61
	0	1	2	2	2
2	42	0	168	108	94
	8	0	176	15	22
	1	0	2	1	1
3	127	176	0	70	143
	3	168	0	29	19
	2	2	0	1	1
4	70	15	29	0	19
	21	108	70	0	4
	2	2	1	0	1
5	61	22	19	4	0
	13	94	143	19	0
	2	1	1	1	0

Note—Side of line relationships are coded 0, 1, or 2 for on-line, same side of the line, and opposite side of the line, respectively.

Table 12
Location of Animal Number 1 Over All Observations

	1	2	3	4	5	6	7	8	9	10	Totals
10	0	0	0	0	0	0	0	0	0	1	1
9	0	0	0	0	0	1	0	1	0	0	2
8	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	1	0	1
6	0	0	0	0	0	0	1	0	0	0	1
5	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	1	0	1
3	0	0	0	0	0	0	0	1	0	0	1
2	1	0	0	0	0	0	1	0	0	0	2
1	0	0	0	0	1	0	0	0	0	0	1
Total	1	0	0	0	1	1	2	2	2	1	

REFERENCES

- BEILHARZ, R. G., & MYLREA, P. J. Social position and behavior of dairy heifers in yards. *Animal Behavior*, 1963, **11**, 522-528.
- CLARK, P. J., & EVANS, F. C. Distance to nearest neighbor as a measure of spatial relationships in populations. *Ecology*, 1954, **35**, 445.
- GOODALL, D. W. Quantitative aspects of plant distribution. *Biological Reviews*, 1952, **27**, 194.
- KILGOUR, R. Social behavior in the dairy herd. *New Zealand Journal of Agriculture*, 1969, **119**, 34.
- KUMMER, H. Spacing mechanisms and social behavior. In J. F. Eisenberg & W. S. Dillon (Eds.), *Man and beast: Comparative social behavior*. Washington: Smithsonian Institution, 1971.
- MCBRIDE, G., JAMES, J. W., & SHOFFNER, R. N. Social forces determining spacing and head orientation in domestic hens. *Nature*, 1963, **197**, 1272-1273.
- SYME, L. A., SYME, G. J., WAITE, T. G., & PEARSON, A. J. Spatial distribution and social status in a small herd of dairy cows. *Animal Behavior*, 1975, **23**, 609-614.

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