A Preliminary Investigation into Mathematical Properties of the Field in Which Every Point Is Defined by the Reciprocal of the Distance from the Boundary

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A Preliminary Investigation into Mathematical Properties of the Field in Which Every Point Is Defined by the Reciprocal of the Distance from the Boundary

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The boundary with fence built around the field is necessary to prevent animals from escaping. This study was designed, apart temporarily from animal agriculture, to investigate mathematical properties of the field in which every point was defined by the reciprocal of the distance from the boundary. The results obtained were as follows. (1) The larger the boundary size was, the lower the rate at which the reciprocal of the distance increased when approaching the boundary from the center of the field. (2) The boundary size did not influence the rate at which the reciprocal of the distance decreased when moving outside the boundary. (3) When based on the reciprocal of the distance from the boundary, getting through the boundary was to get over the gap of ∞ mathematically. (4) Applying the present results to psychological responses that animals might make to every point in the field surrounded by electric fence remains to be investigated. It was suggested that mathematical properties of the field were explained by the boundary size and the reciprocal of the distance from the boundary to every point in the field.

INTRODUCTION

There is usually a boundary (edge, border) that surrounds the agricultural field. The plants planted at or near the border are not included in the samples for collection because of the edge effect on and the immovability of plants. However, in the case of animals that move around, the edge effect is taken into account when collecting the data for animals. Any point in the filed at which the animal stands or lies is designated using the distance from the boundary. There is another designation that is defined by the reciprocal of the distance from the boundary. This is used as the psychological distance in studies of personal relations in humans, as reviewed by Ohnogi (2009).

The present study was designed, apart temporarily from animal agriculture, to investigate mathematical properties of the field in which every point was defined by the reciprocal of the distance from the boundary.

THE FIELD IN WHICH EVERY POINT IS DEFINED BY THE RECIPROCAL OF THE DISTANCE FROM THE BOUONDARY

Field with boundary

Let us suppose a rectangular field (a m × b m) that is surrounded by the boundary (2ab m in length), where every point both inside and outside the boundary is taken into account. This field is, in the present study, regarded as a mathematical plane.

Giving the reciprocal of the distance from the boundary to every point both inside and outside the boundary

Every point inside the boundary

The field is projected on x–y plane. In the present study, coordinates in the first quadrant are taken up. The reciprocal of the distance from the boundary is given to every point inside the boundary using the following coordinates,

$$\left(\frac{1}{a-x},\ \frac{1}{b-y}\right), \tag{1}$$

where x = distance from the origin along x–axis, y = distance from the origin along y–axis, $0 \le x < a$, $0 \le y < b$.

Every point outside the boundary

The reciprocal of the distance from the boundary is given to every point outside the boundary using the following coordinates,

$$\left(\frac{1}{x-a},\ \frac{1}{y-b}\right), \tag{2}$$

where x = distance from the boundary along x–axis, y = distance from the boundary along y–axis, $a < x$, $b < y$.

Dynamics of the reciprocal of the distance in five cases

The center of the field

The center of the field (the origin on x–y plane), when given the reciprocal of the distance from the boundary, is designated by the following coordinates,

$$\left(\frac{1}{a-x},\frac{1}{b-y}\right) = \left(\frac{1}{a},\ \frac{1}{b}\right), \tag{3}$$

where $x = 0$, $y = 0$.

The larger the boundary size (longer a and b) is, the

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lower the reciprocal distance is at the center of the field.

Approaching the boundary from the center of the field

When approaching the boundary from the center of the field, corresponding coordinates are given by

$$F(x) = \frac{1}{a-x}, \quad G(y) = \frac{1}{b-y}, \tag{4}$$

where $0 \leq x < a$, $0 \leq y < b$.
When approaching the boundary from the center of the field, the larger the boundary size (longer a and b) is, the lower the rate at which the reciprocal of the distance, $F(x)$ and $G(y)$, increases with the increase in x and y.

Moving outside the boundary

When moving outside the boundary, corresponding coordinates are given by

$$f(x) = \frac{1}{x-a}, \quad g(y) = \frac{1}{y-b}, \tag{5}$$

where $a < x$, $b < y$.
When moving outside the boundary, there is no effect of the boundary size on the rate at which the reciprocal of the distance, $f(x)$ and $g(y)$, decreases with the increase in x and y.

Moving infinitely outside the boundary leads to zero,

$$\lim_{\substack{x\to\infty \\ y\to\infty}} = \left(\frac{1}{x-a}, \frac{1}{y-b} \right) = (0, 0). \tag{6}$$

On the boundary

There are no coordinates of the reciprocal of the distance on the boundary, because $a \neq x$ and $b \neq y$. When based on the following (7),

$$\lim_{\substack{x\to a \\ y\to b}} = \left(\frac{1}{a-x}, \frac{1}{b-y} \right) = (\infty, \infty),$$

$$\lim_{\substack{x\to a \\ y\to b}} = \left(\frac{1}{x-a}, \frac{1}{y-b} \right) = (\infty, \infty), \tag{7}$$

the infinity shows that the boundary is regarded as singularity.

Getting through the boundary

When based on the singularity in (7), getting through the boundary is to get over the gap of ∞ mathematically.

Relationships between the distance from the boundary and its reciprocal

Every point in the field is given the distance from the boundary or its reciprocal, except the points on the boundary that are not defined by the reciprocal of the distance. The product of the distance and its reciprocal gives the value of '1' to every point, except the boundary. Thus,

$$\frac{a-x}{a-x} = 1, \quad \frac{b-y}{b-y} = 1, \quad 0 \leq x < a, \quad 0 \leq y < b, \tag{8}$$

$$\frac{x-a}{x-a} = 1, \quad \frac{y-b}{y-b} = 1, \quad a < x, \quad b < y. \tag{9}$$

The points on the boundary are indefiniteness as follows,

$$\frac{a-x}{a-x} = \frac{0}{0} = \text{indefiniteness},$$

$$\frac{b-y}{b-y} = \frac{0}{0} = \text{indefiniteness}, \tag{10}$$

where $x = a$, $y = b$,

$$\frac{x-a}{x-a} = \frac{0}{0} = \text{indefiniteness},$$

$$\frac{y-b}{y-b} = \frac{0}{0} = \text{indefiniteness}, \tag{11}$$

where $x = a$, $y = b$.
Do these suggest that the points on the boundary take any value one after another or take all values simultaneously?

Nothing prohibits every point in the field from becoming a boundary. Therefore, it is relative for every point to take the value of '1' or to take any value as the product of the distance and its reciprocal. If based on this mathematical viewpoint, boldly writing at the risk of making mistakes, is every point in the field hypothetically filled with various values?

Is the reciprocal of the distance from the boundary related to psychological phenomena?

Let's get back to the agricultural field. When animals are kept in the field, the fence is built to prevent animals from escaping. If the electric fence is built, assessing psychological responses that animals make is an issue of importance. The reciprocal of the distance from the electric fence might be related to the electric fence–induced psychological tension index allotted to every point in the field. This suggests the concept of dynamic field, where animals might be expected to interact with every point in the field surrounded by the electric fence. Escaping the boundary is to get over the gap of ∞ when interpreted from the mathematical viewpoint. What does this mean from the psychological viewpoint?

Conclusions

It is suggested from the present study that mathematical properties of the field are explained by the boundary size and the reciprocal of the distance from the boundary to every point in the field.

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