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Pseudo–Relativistic Vector Analysis of Animal Growth in Four–Dimensional Space–Time – Preliminary Report with Problem of Dimensional Inconsistency between Space and Time –

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This study investigated the space–time relationship in the growth analysis of an individual animal by introducing a pseudo–relativistic vector, under the problem of dimensional inconsistency between space and time. Space and time were treated equally and growth vector inclining to space–time axes was introduced. The growth vector (***G***) of the animal was described using a pseudo–relativistic vector in four–dimensional space–time, ***G*** = (*x, y, z, t*). The magnitude of ***G*** (*Gm*) was regarded as an index of the four–dimensional growth of the animal. The results obtained were as follows. (i) If ***G*** inclined greatly to *z*–axis compared with the other three axes (*x, y, t*), then this was a result of the fact that the animal became taller by the efficient utilization of the height direction in space. (ii) If ***G*** inclined greatly to *t*–axis compared with space axes (*x, y, z*), then this was a result of the fact that the animal showed a smaller growth because of the inefficient utilization of time. (iii) An invariant connecting geometric and analytic representations of growth was proposed to make an inclusive comparison of various cases of animal growth. It was suggested that space and time were related in a pseudo–relativistic vector analysis of animal growth, under geometric and analytic representations.

Key words: Animal growth, four dimension, pseudo–relativity, space–time, vector analysis

INTRODUCTION

The animal production is influenced by how efficiently the animal utilizes space and time for its growth. The animal growth is usually analyzed along one–dimensional time axis or along three–dimensional space axes. This is a traditional growth analysis method that has a long history, where space and time is treated separately. If four–dimensional space–time is applied, then this may give information on which of space and time is efficiently utilized for the animal production. Shimojo *et al.* (2009) proposed a quasi–four–dimensional growth model to analyze the weight–space–time relationship in an individual plant or animal, but this issue is very complicated.

The present study investigated the space–time relationship in the growth analysis of an individual animal by introducing a pseudo–relativistic vector, under the problem of dimensional inconsistency between space and time.

PSEUDO–RELATIVISTIC VECTOR ANALYSIS OF ANIMAL GROWTH

Description of the growth of an individual animal using a pseudo–relativistic vector

The growth vector (***G***) of an individual animal is hypothetically described using a pseudo–relativistic vector in four–dimensional space–time. Thus,

$$\boldsymbol{G} = (x,\ y,\ z,\ t), \tag{1}$$

where x = width (cm), y =depth (cm), z = height (cm), t = time (day).
The above units are one example. There is a problem of dimensional inconsistency between space and time in ***G***. However, treating space and time equally and introducing ***G*** that inclines to space–time axes might be related to pseudo–relativistic characteristics.

Geometric representation of four–dimensional growth

The magnitude of ***G*** (*Gm*) is regarded hypothetically as an index of the four–dimensional growth of an individual animal. Thus,

$$Gm = \sqrt{x^2+y^2+z^2+t^2}\ , \tag{2}$$

$$Gm \cdot \cos\alpha = x, \tag{2–1}$$

$$Gm \cdot \cos\beta = y, \tag{2–2}$$

$$Gm \cdot \cos\gamma = z, \tag{2–3}$$

$$Gm \cdot \cos\delta = t, \tag{2–4}$$

where α = the angle between ***G*** and x–axis, β = the angle between ***G*** and y–axis, γ = the angle between ***G*** and z–axis, δ = the angle between ***G*** and t–axis.
It is possible to describe the space axes, but it is impossible to describe the time axis whose direction is invisible. Thus, only the angle between ***G*** and t–axis is hypothesized.

Two examples of the geometric representation of the four–dimensional growth are as follows. (i) If ***G*** inclines

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greatly to z–axis compared with the other three axes (x, y, t), then this is a result of the fact that the animal becomes taller by the efficient utilization of the height direction in space. (ii) If $\boldsymbol{G}$ inclines greatly to t–axis compared with space axes (x, y, z), then this is a result of the fact that the animal shows a smaller growth because of the inefficient utilization of time. These interpretations are based on the following. If $x > y > z > t$, then $\alpha < \beta < \gamma < \delta$; namely $\cos\alpha > \cos\beta > \cos\gamma > \cos\delta$.

Analytic representation of four–dimensional growth

We will hypothesize that the rates of growth along space–time axes are given by the partial differentiation of Gm. Thus,

$$\frac{\partial Gm}{\partial x} = \frac{x}{\sqrt{x^2+y^2+z^2+t^2}}\,, \tag{3-1}$$

$$\frac{\partial Gm}{\partial y} = \frac{y}{\sqrt{x^2+y^2+z^2+t^2}}\,, \tag{3-2}$$

$$\frac{\partial Gm}{\partial z} = \frac{z}{\sqrt{x^2+y^2+z^2+t^2}}\,, \tag{3-3}$$

$$\frac{\partial Gm}{\partial t} = \frac{t}{\sqrt{x^2+y^2+z^2+t^2}}\,. \tag{3-4}$$

The comparison with the preceding section suggests that the analytic representation using the partial differentiation of Gm is the same as the geometric representation using the cosine function of Gm.

Geometric and analytic invariant

There is an invariant that is conserved by the geometric and analytic representations where every term is squared. Thus,

$$\left(\frac{\partial Gm}{\partial x}\right)^2+\left(\frac{\partial Gm}{\partial y}\right)^2+\left(\frac{\partial Gm}{\partial z}\right)^2+\left(\frac{\partial Gm}{\partial t}\right)^2$$

$$= \cos^2\alpha + \cos^2\beta + \cos^2\gamma + \cos^2\delta$$

$$= 1. \tag{4}$$

This invariant suggests that each of the four dimensions is related to the other three. Expression (4) might be applied to an inclusive comparison of various cases of animal growth.

Growth force (the product of growth (Gm) and growth acceleration)

We will hypothesize that the acceleration of the growth along x–axis is given by

$$\frac{\partial^2 Gm}{\partial x^2}$$

$$= \frac{1}{\sqrt{x^2+y^2+z^2+t^2}} \cdot \frac{y^2+z^2+t^2}{x^2+y^2+z^2+t^2}$$

$$= \frac{1}{Gm} \cdot \left(\left(\frac{\partial Gm}{\partial y}\right)^2+\left(\frac{\partial Gm}{\partial z}\right)^2+\left(\frac{\partial Gm}{\partial t}\right)^2\right). \tag{5}$$

This leads to the growth force (the left–hand side of expression (5–1)) along x–axis,

$$Gm\left(\frac{\partial^2 Gm}{\partial x^2}\right)=\left(\frac{\partial Gm}{\partial y}\right)^2+\left(\frac{\partial Gm}{\partial z}\right)^2+\left(\frac{\partial Gm}{\partial t}\right)^2, \tag{5-1}$$

and likewise,

$$Gm\left(\frac{\partial^2 Gm}{\partial y^2}\right)=\left(\frac{\partial Gm}{\partial z}\right)^2+\left(\frac{\partial Gm}{\partial t}\right)^2+\left(\frac{\partial Gm}{\partial x}\right)^2, \tag{5-2}$$

$$Gm\left(\frac{\partial^2 Gm}{\partial z^2}\right)=\left(\frac{\partial Gm}{\partial t}\right)^2+\left(\frac{\partial Gm}{\partial x}\right)^2+\left(\frac{\partial Gm}{\partial y}\right)^2, \tag{5-3}$$

$$Gm\left(\frac{\partial^2 Gm}{\partial t^2}\right)=\left(\frac{\partial Gm}{\partial x}\right)^2+\left(\frac{\partial Gm}{\partial y}\right)^2+\left(\frac{\partial Gm}{\partial z}\right)^2. \tag{5-4}$$

Each growth force is related to the sum of the other three growth rates squared, which seems to be a space–time continuum. This might be related to a pseudo–relativistic characteristic of the four–dimensional growth of an individual animal.

The sum of expressions (5–1)~(5–4) gives

$$Gm\left(\frac{\partial^2 Gm}{\partial x^2}+\frac{\partial^2 Gm}{\partial y^2}+\frac{\partial^2 Gm}{\partial z^2}+\frac{\partial^2 Gm}{\partial t^2}\right)$$

$$= 3\left(\left(\frac{\partial Gm}{\partial x}\right)^2+\left(\frac{\partial Gm}{\partial y}\right)^2+\left(\frac{\partial Gm}{\partial z}\right)^2+\left(\frac{\partial Gm}{\partial t}\right)^2\right), \tag{6}$$

$$= 3(\cos^2\alpha + \cos^2\beta + \cos^2\gamma + \cos^2\delta), \tag{7}$$

$$= \sin^2\alpha + \sin^2\beta + \sin^2\gamma + \sin^2\delta, \tag{8}$$

$$= 3. \tag{9}$$

Expressions (6)~(9) suggest a hypothesis that growth force is a fundamental concept for the analytic and geometric representations of animal growth in four–dimensional space–time.

Conclusions

This study suggests that space and time are related in a pseudo–relativistic vector analysis of animal growth, under geometric and analytic representations.

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