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Analysis and Modeling of Ants' Behavior from Single to Multi-body

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Abstract: This paper addresses the fluctuating of ants' behavior. Firstly, we report the case of single ant, focusing on the fluctuation of the walk. We found the fluctuations of travel distance and the variance of ant-body direction obey power laws on the time interval. Secondly, we discuss the behavior of several ants from the respect of social insects. The primary result shows a collective behavior of two ants.

Keywords: fluctuation, social insects, multi-body dynamics

I. INTRODUCTION

Social insects exhibit a number of remarkable behaviors, such as colony formation, group foraging. These collective behaviors do not require a special individual that controls the behavior of the entire group. Hereditarily homogeneous individuals achieve these collective behaviors by interacting with each other through direct sight or chemical materials, such as pheromones. However, compare to the study of collective behaviors of ants, few researches have studied the behavior of single ant[1-3].

In this research, we firstly studied the fluctuation of velocity on ant walk. It is because fluctuations play a key role on micro to macro scale in biological system.

As a next step, we focus on the fluctuation of distance between several ants and discuss multi-body dynamics of several ants.

This kind of phenomena is very attractive not only for biologists or scientists but also engineers. In robotics, especially, many researchers have investigated multi-robot systems, and some of them were inspired by such biological systems and analyzed their performance using real robot systems[4]. We consider that this kind of research can provide fundamental elements for a multi-robot model consisting of simple elements and external variables.

II. Methods and Analysis

We recorded the behavior of single to several ants under the environment without a nest and food. In the case of several ants, ants are placed in hemisphere (30cm in diameter) to avoid the boundary condition, i.e., ants are less biased to walk on the boundary due to the sense of gravitational attraction.

(i) Analysis of single ant; we measured the time- series of increments of velocity and body direction.

(ii) Analysis of several ants; we measured the distance between ants as a function of time.

III. Results and Discussion

1. Fluctuation of single ant

(1)Time correlation of walking velocity

From the spectrum of walking velocity, we can see a long-term correlation in the velocity dispersion as shown in Fig.1. We also found the fluctuation is in proportion to the time scale ($\sigma_L \propto \Delta t^{\alpha}$), where $\alpha > 0.5$ (Fig.1).

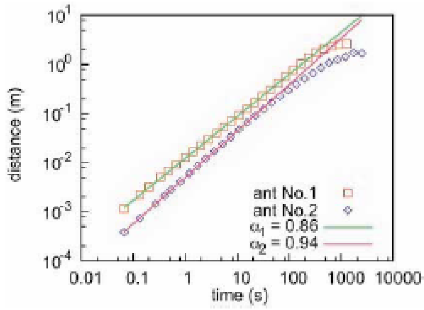

Fig.1: Dispersion of the walking velocity as a function of time

(2)Time correlation of body direction

From the spectrum of body direction, we found there is a short-term correlation (less than 1 sec), but not long-term correlation here (Fig.2). In spite of long-term correlation in velocity, from the actual value of average velocity and the velocity dispersion, we can regard ants as a random walker.

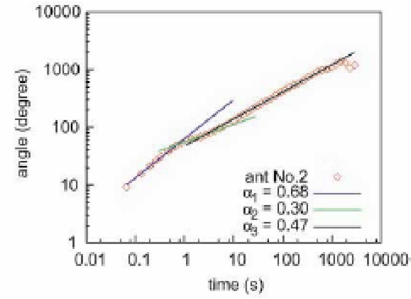

Fig.2: Dispersion of the body direction as a function of time.

2. Analysis of multi-body dynamics of ants behaviors

Fig.3 shows the distance between two ants as a function of time after placing two ants in the hemisphere. The distance profile shows dynamic profile; they meet and part away every 6 minutes on average in first two hours. We found that they spontaneously gather, interacting through direct sight or chemical materials. Tracking of single ant shows that space distribution of ant position is localized(Fig.4). From the tracking of two ants, it can be concluded that two ants meet at the certain position. Velocity profile of two ants can be interrupted as three stages as a function of time (Fig. 5).

(1)At Stage I, both of two ants are active, i.e., they travel around the surface of hemisphere.

(2)At Stage II, one of them becomes inactive. There seems to be an exchange of active and inactive role between two ants; one of them halt at a certain place and the other explore the surface of hemisphere.

(3)At Stage III, both of them become inactive, i.e., they halt at one place in contact distance.

IV. CONCLUSION

1. Walking behavior of single ant can be regarded as random walker.
2. Spontaneous meeting process is observed between two ants.
3. Primary result on division of labor is obtained between two ants.

In this paper, we reported some primary results. More experiments on multi-body dynamics of ants behavior are in progress. Based on experimental results, we will propose a model of multi-task allocation.

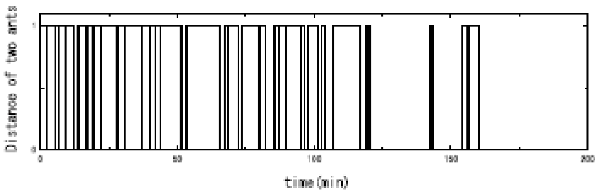

Fig.3: Distance between two ants as a function of time (distance is recorded in binary condition; zero denotes when two ants are in contact, one denotes when they are not in contact)

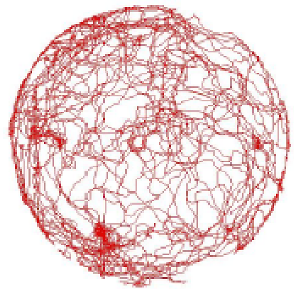

Fig.4: Trajectory of single ant(the other not shown) in hemisphere

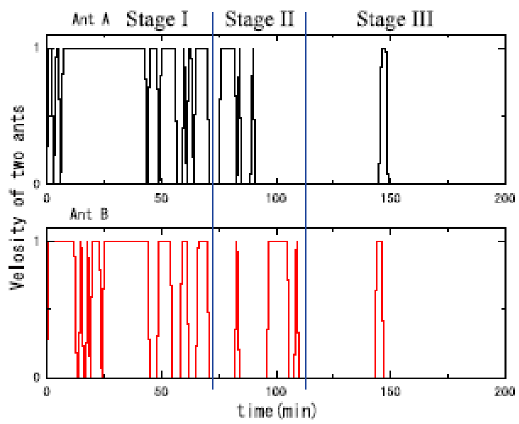

Fig.5: Velocity of two ants as a function of time (velocity is recorded in binary condition; zero denotes when two ants are in halt, one denotes when they travel)

REFERENCES

[1] Mandelbrot BB, Van Ness JW (1968), Fractal Brownian Motions, Fractal Noises and Applications, SIAM Rev. 10, 422-437

[2] Cole BJ (1992), Short-term activity cycles in ants, Behav. Ecol. Sociobiol. 31, 181-187

[3] Cole BJ, Cheshire D (1996), Mobile Cellular Automata Models of Ant Behavior, Am. Naturalist 148, 1-15

[4] Bekey GA (2005), Autonomous Robots: From Biological Inspiration To Implementation And Control, MIT Press