SWIMMING ANALYSIS OF SMALL AQUATIC INSECT AND FLOW CHARACTERISTICS AROUND SWIMMING ROBOTS

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INTRODUCTION

In the field of the latest robotics, the study of various locomotive functions and mechanisms of small animals is of fundamental interest and importance with respect to the development of various micro robots. Recent advances in integrative studies of locomotions are reviewed to shed light on the physical relationships among habitat farm, way of life, and mode of movement in living creatures[1]. Most of aquatic animals oscillate swimming appendages, undulate, and produce periodic propulsive forces so that the velocity of some part of their bodies changes in time[2]. The gereration mechanism of the unsteady flow about swimming animals is important in the development of swiimming robots. In this paper, the swimming analysis of water beetles is conducted with a high speed video camera system. Based on the swimming analysis of water beetle, the micro swimming robot with the wireless energy supply system is produced. Frequency characteristics for the swimming velocity of the micro swimming robot propelled by the alternating magnetic field are examined experimentally.

EXPERIMENTAL APPARATUS AND PROCEDURE

A schematic diagram of the experimental apparatus to study swimming behavior of water beetles is shown in Figure 1. The experimental apparatus consists of the swimming water container system, the optional measurement system, and the analysis system. The rectangular container used in the experiments is made of the glass. The aquatic insect is released in the water container and chased with the light beam. Free swimming behavior of the water beetle is observed with the high speed video camera. A series of frames of free swimming behavior of water beetle are analyzed by the personal computer.

The micro swimming robot is developed based on the kinetic analysis of swimming behavior of water beetles. The swimming robot is propelled by the magnetic torque acting on the NdFeB magnet in the alternating magnetic field. A block diagram of the experimental apparatus is shown in Figure 2.

EXPERIMENTAL RESULTS AND DISCUSSION

Figure 3 shows a sequence of photographs showing the free swimming of water beetle. It can be seen that the water beetle swims by flexing his hind legs together. During the power stroke, they are stretched and move backward. The water beetle swims by paddling its hindlegs. The hindlegs are folded and narrowed during the recovery stroke. The thrust-generating mechanism is the fluid dynamic drag of the leg movement.

Based on the above-mentioned swimming analysis of the water beetle, the micro swimming robot was produced by trial and error. Figure 4 shows the frequency characteristics of swimming velocity for the swimming robot. In Figure 4, v is the swimming velocity, l is the fin length, and w is the fin width. The effect of the applied voltage E is also shown in Figure 4.The increase in applied voltage corresponds to the increase in the magnetic field generated by the coil. The swimming velocity depends on the frequency of alternating magnetic field, f_0. The spectrums of the swimming velocity have the peaks. Flow visualization was created by floating powder tracer on the water surface. Swimming robot generated some vortexes on the water surface at the coordinate system fixed to the robot.

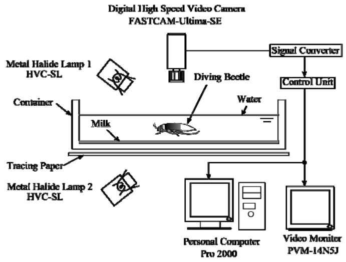

Figure 1: Experimental apparatus for swimming analysis.

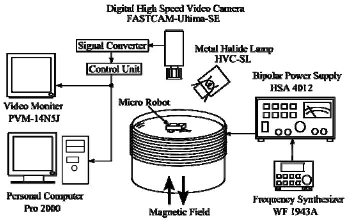

Figure 2: Schematic diagram of experimental apparatus.

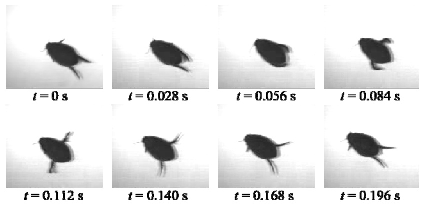

Figure 3: Swimming behavior of water beetle.

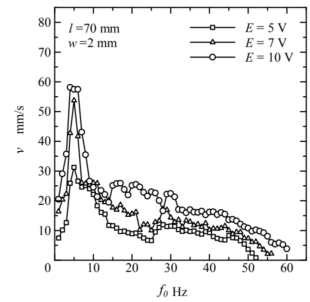

Figure 4: Frequency characteristics of swimming robot.

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