Estimation of firing pattern of primary afferents from joint kinematics during voluntary arm movements of monkeys*

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Abstract—Understanding the information of firing pattern of peripheral afferents is important for determining the optimal parameters of primary afferent stimulation to transmit the sensory signal in bidirectional brain machine interfaces. To investigate whether the temporal firing pattern of dorsal root ganglion (DRG) neurons could be estimated from the forelimb joint kinematics of behaving macaque monkeys, we implanted 2 multi-electrode arrays chronically in the DRGs at the level of C7 and C8 spinal segments of two monkeys. Sixteen and 14 neurons were recorded in Monkey 1 and 2, respectively. For a subpopulation of neurons, the temporal firing pattern could be reconstructed precisely from forelimb joint kinematics using the sparse linear regression algorithm (SLiR) and an integrate and fire model. The results suggest that the estimation method from forelimb joint kinematics of behaving monkeys can be useful for designing sensory feedback systems.

I. INTRODUCTION

Peripheral sensory afferents are candidate sites for the application of sensory feedback signal in bidirectional brain machine interfaces. Understanding the firing pattern of peripheral afferents is important for determining optimal parameters of primary afferent stimulation to transmit the sensory signal. Previously, we showed that the temporal firing patterns of DRG neurons have enough information of joint kinematics of a passively moved forelimb of anesthetized monkeys [1]. In this study, we investigated whether the temporal firing pattern of DRG neurons can be estimated from the forelimb joint kinematics of behaving monkeys.

II. METHODS AND RESULTS

Two multi-electrode arrays (48 electrodes each) were implanted chronically in the C7/8 DRGs of two monkeys. Monkeys performed reaching and grasping task to pull a target lever or to take a food pellet. Neuronal responses to the movements were recorded simultaneously. The 3-D trajectories of hand/arm movements were tracked using an optical motion capture system. Three kinematics (angle, angular velocity and acceleration) of shoulder, elbow, wrist and finger joints were calculated from positional information of markers attached to 14 or 5 sites on the forelimb in the Cartesian coordinate system in Monkey 1 and 2, respectively. Neuronal firing rates for each unit and sampling of the motion capture system were computed at 5-ms bins. After the spike sorting method, 16 and 14 neurons were isolated in Monkey 1 and 2, respectively. Among those neurons, 14 and 10 neurons responded to the reaching and grasping movements.

To elucidate the decoding of firing frequency of DRG neurons by forelimb joint kinematics, we applied the SLiR, which automatically selected appropriate feature sets from explanatory variables to attain a better generalization performance, to forelimb joint kinematics of Monkey 1. We used kinematics data for 100 ms immediately before estimated neuronal firing rates. The temporal firing pattern of units were calculated from the acquired firing frequency using the integrate and fire model. Result of the decoding is shown in Fig. 1. Thus, for a subpopulation of neurons, their temporal firing pattern can be reconstructed precisely from forelimb joint kinematics using the encoding model.

Figure 1. Estimation of DRG neuronal activity from forelimb joint kinematics using SLiR and integrate and fire model

REFERENCES


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