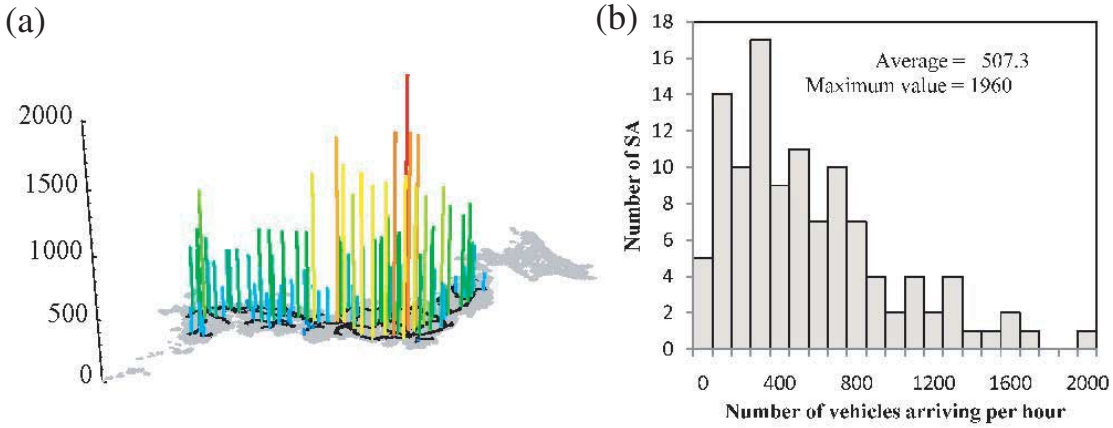

Fig. 8. Estimated number of vehicles arriving at SAs per hour (cont. driving range = 120 km). (a) Distribution. (b) Histogram.

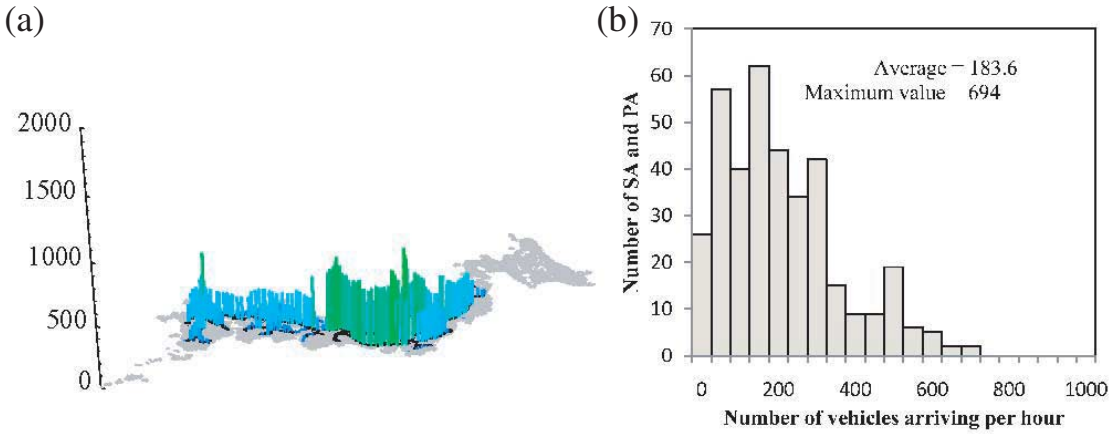

Fig. 9. Estimated number of vehicles arriving at SAs and PAs per hour (cont. driving range = 120 km). (a) Distribution. (b) Histogram.

Okinawa Prefectures (these are separated islands and not connected by strait bridge).

In this research, we calculated the number of charging facilities and number of vehicles arriving at these facilities. We assume that the vehicles driving in the target network were all replaced with EVs. Japanese highway networks are very busy currently; therefore, a calculation that replaces currently used vehicles with EVs is necessary. We prepared the real OD traffic volume between the ICs provided by Nippon Expressway Company Limited (Central Nippon Expressway Company Limited, 2012; East Nippon Expressway Company Limited, 2012; West Nippon Expressway Company Limited, 2012), which was 12 h of traffic in a weekday. The total number of vehicles in the OD matrix was 965,338,579.

4.2 Estimation result

We first analyzed the most probable estimation result based on our mathematical model. For the initial power-feed pattern, we assumed $q(t)$ to be a uniform function, because the remaining battery amount of EVs on highways would be varying. Meanwhile, for the power-feed pattern after recharging, we assumed $p(t)$ to be a linear function, because recharged EVs would be driven till their capacity. These assumptions of $q(t)$ and $p(t)$ are stable in the rest of this section.

It is very likely for EV charging facilities to be installed at SAs only in early stage of EV diffusion. This means that EVs can skip one SA at a maximum ($T = 2$) because SAs are located at intervals of approximately 60 km and the continuous driving range after quick charging is 120 km. The calculation results are shown in Fig. 8. As shown in the figure, when charging facilities are installed only at SAs, the number of vehicles arriving at the facilities is high because of the few facilities, and the number of vehicles arriving per hour is approximately 500–1,960. Now, we assume that each EV occupies the charging station for approximately 35 min on average (we considered storing, charging, and retrieving) and the number of SA parking slots is 250, and the actual diffusion rate of EVs is α. Here, similar to the discussion in Section 2, EV charging facilities should be considered to follow the queueing model, and $\lambda/s\mu < 1$ must be satisfied. That is,

$$\frac{1{,}960 \times \alpha}{250 \times \dfrac{60}{35}} < 1$$