**Manuscript Ref. No:** XXXX

**Title:** Deep Learning based Energy-efficient Computational Offloading in Internet of Vehicles

**Authors' Responses to the Reviewers' Comments**

We are grateful to the reviewers for their constructive suggestions to help me to improve the quality of the manuscript. We have carefully considered their comments and recommendations and have revised the manuscript accordingly. The followings are detailed explanations on how we have addressed the reviewers' comments in the revised manuscript.

**Response to Reviewer 1**

*In recent years, both fog and cloud computing offloading models are proposed to improve the computation performance and support computing-intensive applications in IoV. This article comprehensively considers the delay and power consumption of offloading model and present a fog-cloud offloading model to minimize the power consumption with the constraint of delay. Since the formulated problem is an NP-hard problem, the authors design a heuristic method and a deep learning algorithm for solving the optimal solution. This work is attracting and solid. The reviewer has the following concern:*

*1. As mentioned in Section I, fog computing has lots of advantages compared to the cloud, why not just take the fog model as the offloading model?*

**Response:** We would like to thank the Reviewer 1 for the constructive comments and suggestions which have helped us to improve the quality of this paper. We explain the disadvantages of the cloud model in our paper, whereas it is necessary to keep the cloud centers in our proposal model. In Section V, fig 3 illustrates the performance of different models. From these simluation results, we can conclude that the computation capability of fog-only model is not up to coping with the delay-growth under high workload. The cloud center can enhance the robustness of the offloading model. The explanation above has been added to the second paragraph of section I.

*2. As mentioned in Section Ⅲ, vehicles can connect to the fog or cloud nodes through RSUs. RSUs have a low coverage. If RSU is not available, how to cope with this problem? Is it possible to connect the network through other method such as through cellular base station?*

**Response:** Thanks for the suggestion. In the revised version, we have added some alternative ways, such as through cellular base station, to access to the network for vehicles in the first paragraph of section III. In this paper, we mainly focus on improving the performance in RSU mode. These alternative methods are the prospect for the future.

*3. As mentioned in Section Ⅳ, the greedy algorithm has poor performance compared to the heuristic algorithm. It is supposed to explain more details about the disadvantages of greedy algorithm.*

**Response：**Thanks for your kind advice. Compared to the heuristic algorithm, the greedy algorithm has pressed a strict delay constraint on each requst . The delay performance of greedy algorithm is excellent while the energy consumption of that is huge. The explanation above has been added to the last paragraph of secion V.

*4. Since the simulated annealing algorithm has a better performance than the deep learning model, why not take the simulated annealing algorithm as the optimal algorithm.*

**Response:** Thanks for your question. The simulated annealing algorithm is used to solve the approximate optimal solutions which is the label data of the deep learning model. Thus, as far as the result is concerned, simulated annealing algorithm is better than the deep learning algorithm. Whereas the simulated annealing algorithm is time-consuming in execution. The deep learning algorithm can quickly obtain the approximate optimal solutions through the trained network. In summary, we take the deep learning algorithm as the optimal algorithm for its advantage of time saving. We have added more explanations in the last paragraph of section V.

*5. The reviewer wonders whether the approximate optimal solution can be obtained each time by the deep learning algorithm. If not, how to cope with this problem.*

**Response:** Thank you for your question. Indeed, it is impossible for deep learning algorithm to get the appropriate results. In the simulation, we take the greedy algorithm as the compensation when the incorrect results are obtained by the deep learning algorithm.

**We thank Reviewer 1 again for the constructive comments and suggestions which have helped us to enhance the quality of this paper.**

**Response to Reviewer 2:**

*This article dealt with one of the well-known problem for vehicles in the fog-cloud computing literature, which is named as computing offloading problem. Because the formulated problem has high computational complexity, a heuristic algorithm based on deep learning is proposed to minimize the energy consumption with delay constraint in the offloading model. Finally, performance evaluations demonstrate the superiority of the proposal algorithm. Although this paper is good, it would be ever better if some extra data were added. A few concerns are list below:*

*1. As mentioned in Section Ⅰ, the power consumption of computational facility is considered in this paper. Is it really necessary to take that into consideration?*

**Response:**Thanks for your question. There are mainly three types in computing offloading model: minimizing delay, minimizing energy consumption, and minimizing energy consumption while meeting delay constraints. In this paper, we focus on the last type and ,compared with the existing literatures, additional consideration is given to the power consumption of the computational facilities. It is necessary to consider the energy consumption of the computational facilities, as the energy consumption of that is increasing over time.

*2. In the system model, it seems that you just consider the delay of the upload link. Please explain the reasons for ignoring the delay of return.*

**Response:** Thanks for your kind reminding. Generally speaking, the size of upload request packet is much larger than that of returned packet by the request result. Thus, it is reasonable to ignore the delay of return. In the revised version we have added corresponding explainations in the second to last paragraph of subsection III.A .

*3. As mentioned in Section Ⅳ, the fog or cloud nodes have some info records in the last H periods. Is the value of H randomly generated or determined by experience?*

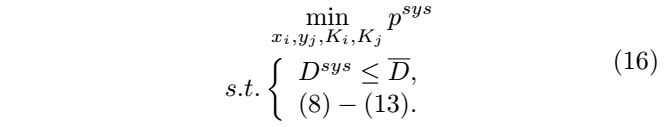
**Response:** Thanks for pointing out this problem. The value of H is related to the CPU frequency and the workload of the tasks, which is not randomly generated. In our simluation we choose the H value with a minimum loss in the deep learning algorithm. We have supplemented the corresponding explanations in the first paragraph of section IV.B.

*4. As we all known, the deep learning algorithm such as CNN has a high computational complexity, how to guarantee the delay.*

**Response:** Thanks for the mentioned problem. Indeed, deep learning algorithms have a high computational complexity in the training process. After training ,in contrast, the deep learning algorithm has a lower computational complexity in the process of calculating offloading results. In our model, the training process is periodically conducted offline and therefore the delay can be guaranteed. We have supplemented the corresponding part in the running phase of subsection IV.B.

*5. I think the formula (16) and (17) should be a whole formula and the location of algorithm Ⅰ pseudocode should be readjusted.*

**Response:** Thank you for your careful check. Formula 16 and 17 are the same formula separated by the pseudocode. We have repositioned the pseudocode and the formula in the revised version. We have also carefully checked other parts of this article to avoid the mentioned problem. The revised formula is as follows:



*6. Some symbols in table Ⅰ are useless in this paper. I suggest you to modify the table I to make it sample and useful.*

**Response:** Thank you for your careful check. The information in Table I is imperfect. In the revised version we have modified and simplified table I. We have also carefully checked other parts of this article to avoid the mentioned problem.

**We thank Reviewer 2 again for the constructive comments and suggestions which have helped us to enhance the quality of this paper.**