論文 / 著書情報
Article / Book Information

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種別(和文)	論文要旨
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（博士課程）
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論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	電気電子　系 電気電子　コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　（工学）
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

The combination of sensors with wireless communication has great advantages over the conventional driving systems in terms of safety and reliability. This technique is often called cooperative perception, and it is expected to compensate for blind spots in dynamic maps, which can improve the safety and reliability of automated driving. The current researches and works understand the impact of cooperative perception applications. However, the relation between safe automated driving and the performance of wireless communications is not discussed from both disciplines. Therefore, this thesis aims to analyze the relation from not one discipline but both disciplines. Since many cooperative perception applications assume sharing processed sensor data due to the performance of conventional V2X communications, the format of shared sensor data is an important factor. Although sharing raw sensor data requires much larger communication resources than sharing processed sensor data, sharing raw sensor data is necessary to develop high level automated driving vehicles. The necessities come from liability reasons at car accidents, distributed verification of local and remote sensor data, and generating accurate maps, which cannot be achieved by sharing processed sensor data. Including these factors, the analysis derives the maximum required sensor data rate to be exchanged for the cooperative perception in order to enable a new level of safe and reliable automated driving. The other analysis aims to show the ability of millimeter-wave communications, which is expected for new V2X communications, to improve safety.

The thesis consists of simulation part and experiment part. Since real traffic environments are very complicated, the simulations focus on fundamental analysis. It starts from selecting important driving scenarios that often traffic fatalities occur, and overtaking on a two-lane road scenario and passing through an intersection scenario are chosen. The simulations under the selected scenarios consider multiple disciplines such as vehicle behavior, recognition process, and wireless communications to perform comprehensive analysis. Therefore, the relation between safe automated driving and the performance of wireless communications is analyzed in detail. Vehicle behavior considers a path planning of the ego vehicle that is necessary for safe driving. Recognition process that uses practical feature points leads to deriving tight requirements. The performance of wireless communications is calculated to compare safe automated driving realized by cooperative perception that uses conventional and millimeter-wave communications. The experiments perform cooperative perception with millimeter-wave communications at outdoor environment. The measurement of throughput is performed and the results are compared with the results of the intersection scenario.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

The simulations show two results. One is the maximum sensor data rate required for safe automated driving with cooperative perception. These requirements are derived under overtaking on a two-lane road and passing through an intersection. The required sensor data rate rapidly increases in both scenarios as the velocity of the ego vehicle gets increased. The result also shows that the utilization of cooperative perception decreases the required sensor data rate due to increased sensing range. The other result shows the safe automated driving realized by conventional and millimeter-wave V2X communications. It is shown that millimeter-wave communications at 30 and 60 GHz can ensure safe automated driving at 50 and 65 km/h in the overtaking scenario. The result of the intersection scenario shows that 30 and 60 GHz can ensure safe automated driving at 55 and 62 km/h. On the other hand, 5 GHz that is used in conventional V2X communications does not support safe automated driving under these scenarios. The outdoor experiment performs cooperative perception with millimeter-wave communications and raw LiDAR sensor data is shared in real time. The combination of this experiment and the result of the intersection scenario shows that millimeter-wave communications make it possible to cross intersections safely under the campus rules.

These results conclude that millimeter-wave communications have a potential to support sharing raw sensor data that is one type of cooperative perception. Moreover, it is shown that the utilization of cooperative perception improves safe automated driving. Although sharing raw sensor data requires high performance of wireless communications, millimeter-wave communications can meet the requirements and get the benefits that sharing processed sensor data cannot provide. The end of the thesis discusses future perspectives. Although these results focus on fundamental driving scenarios, deriving the requirements with the definition of safety has not been performed by the related works, which is achieved by considering multiple disciplines. However, the extension from these fundamental driving scenarios to different driving scenarios is also important. Adopting new parameters for different scenarios makes it possible to compare the results of this thesis and the results that consider more realistic conditions. This comparison will give us which condition is critical to the required sensor data rate and tell the priority of conditions.