Title	相互作用のあるシミュレーションを統合する都市デジタルツイン基盤の研究
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Research on urban digital twin infrastructure that integrates simulations with interactions

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This research aims to build a digital twin infrastructure for the integration of interacting simulations in urban environments. Urban digital twins are used in a wide variety of fields such as urban planning, energy management, mobility analysis, and smart city applications. However, each of the current digital twins is operated independently, and mutual data sharing is insufficient, making the lack of an integrated framework an issue. In this study, we propose an integrated infrastructure with relationship management and temporal control capabilities to manage the interactions among urban digital twins. In addition, we show that integrating data from different simulations in a city enables more accurate urban analysis. The proposed digital twin integration infrastructure incorporates relationship management using directed graphs and a scheduling mechanism that considers time synchronization to appropriately control interactions among multiple digital twins. In relationship management, the dependency relationship between each digital twin is represented as a graph model, and the stability of the interaction is analyzed to achieve appropriate coordination. In addition, in time control, a scheduling method is introduced to adjust the time axis gap between simulations to improve real-time performance and prediction accuracy. In addition, algorithms will be implemented to optimize data exchange between digital twins to enable smoother interaction. By doing so, we aim to improve the accuracy of simulations in response to changes in the urban environment. Furthermore, to verify the effectiveness of the proposed infrastructure, experiments were conducted using multiple digital twins. In the experiments, we evaluated the performance of execution management based on scenario data, real-time interaction monitoring, and scheduling mechanisms. As a result, we confirmed that the proposed infrastructure improves computational efficiency while ensuring stable interactions in the integration of digital twins. In addition, the impact of data integration was analyzed in detail to determine the optimal parameters to enhance the utility of urban digital twins. As a result, data sharing among digital twins was facilitated, enabling more accurate forecasts. Through this study, it was shown that more accurate urban simulation can be realized by introducing an interaction-aware scheduling mechanism as an integrated foundation for urban digital twins. The results of this research will contribute to the development of smart cities and the creation of a general-purpose digital twin infrastructure to support real-time decision making and scenario analysis. Furthermore, by optimizing the mutual data exchange between digital twins, it will expand the potential for

applications in areas such as urban planning, energy management, and traffic control. In the future, this infrastructure will be further developed and extended as a framework applicable to different urban environments. In this study, we proposed an integrated infrastructure that incorporates relationship management and temporal control, taking into account the interactions of the urban digital twin. As a result, stable interactions and improved computational efficiency were confirmed, indicating that the proposed framework is expected to contribute to the smart city field. It was also found that the proposed integrated infrastructure facilitates the use of urban digital twin and contributes to more advanced urban simulation.