

Fellowship ID : BR250403

2025 年 10 月 20 日

YYYY/MM/DD

独立行政法人日本学術振興会理事長 殿

To: President, Japan Society for the Promotion of Science

研究活動報告書 Research Report

1. 受入研究者/ Host researcher

受入研究機関・部局・職
Name of Host Institution, Department and Title

東京大学・大学院工学系研究科・特任教授

受入研究者氏名
Host Researcher's Name

全 邦釘

2. 外国人招へい研究者/ Fellow

所属研究機関・部局・職
Name of Institution, Department and Title

University of Missouri-Kansas City, Civil and Mechanical Engineering
Department, Professor

外国人招へい研究者氏名
Fellow's Name

ZhiQiang CHEN

3. 採用期間/ Fellowship Period

2025 年 7 月 2 日 ~ 2025 年 7 月 31 日 30 日 (Days)
か月 (Months)

4. 研究課題/ Research Theme

量子コンピューティングの土木インフラレジリエンスと自動化への応用

5. 研究活動報告/ Research Report

(1) 研究活動の概要・成果/ Summary of Research Results

During my one-month JSPS Bridge Fellowship at the University of Tokyo (UTokyo), hosted by Dr. Pang-Chu Chun, our collaborative research sought to advance automation technologies for civil infrastructure operation and management, emphasizing spatial intelligence as a unifying and transformative theme.

Throughout the visit, we engaged in intensive discussions, laboratory visits, and exploratory experiments focusing on two interconnected domains that represent the frontier of intelligent civil infrastructure systems:

- From Point Clouds to Computable Digital Twins.
 - We investigated pipelines that transform unstructured 3D point clouds into computable and updatable digital twins to enable automation in infrastructure inspection and maintenance. The study reviewed recent advances in AI-enabled vision-language models and agentic perception frameworks, which integrate geometric, semantic, and contextual reasoning for damage recognition, asset condition assessment, and decision support.

(注) 採用期間終了後 3 ヶ月以内に提出

※ (Note) Submit the form within 3 months after the expiration of fellowship.

※ 様式 1 に記載された情報を基に確認しますので、部局名等の名称含め、内容に誤りが無いか必ずご確認ください。

- As an immediate outcome, we procured a mobile LiDAR unit (Unitree Lidar L2)—a compact, low-cost, and flexible device capable of simulating both aerial (flying) and terrestrial (ground) mobility. The system is currently under active testing by a graduate researcher at UMKC, forming the nucleus of a shared experimental platform for future graduate and doctoral research between UMKC and UTokyo. This collaborative testbed will serve as a foundation for AI-driven infrastructure automation and remote inspection.
- Quantum Computing for Resource Optimization in Mega-City Infrastructure Networks.
 - Recognizing the inherent limitations of classical and AI-based optimization under deep and transient uncertainties, especially those stemming from human and organizational decision processes, we explored the potential of quantum combinatorial optimization for urban infrastructure resource allocation.
 - The rationale is that while automation technologies such as robotic imaging, digital inspection, and autonomous mobility improve efficiency and responsiveness, they remain bounded by scenario-based reasoning. We envision that quantum computing-enabled optimization algorithms (e.g., Quantum Approximate Optimization Algorithm, QAOA, and variational quantum solvers) could elevate resource management by addressing complex combinatorial constraints across personnel, vehicles, and robotic assets in large-scale disaster response and recovery within mega-cities such as Tokyo.

Collectively, this collaboration produced a shared research roadmap integrating digital twin and quantum computing technologies into a broader spatial intelligence-enabled infrastructure management ecosystem.

Our long-term action items include:

- We aim to co-organize international conference sessions if an appropriate venue emerges.
- The University of Missouri System hosts one of the unique IBM Quantum Innovation Centers (Dr. ZhiQiang Chen is an affiliated faculty, and the only one in Civil Engineering). We envision that with the help of JSPS and NSF, we could develop a joint UM–UTokyo symposium on AI and Quantum Technologies for Smart Infrastructure in 2027
- We plan to develop NSF–JSPS joint (i.e., workshop, education, or research) proposals. The most likely one would be an education/training-focused effort toward developing cross-institutional graduate training modules in AI, digital twins, and applied quantum-computing technologies for resilient infrastructure systems.

(2) 主な研究発表 (雑誌論文、学会、集会、知的財産権等) / Main Research Publications

Publications

As short-term research outcomes, we have established an initial task plan to prepare two comprehensive review articles and identify international conference opportunities for presenting preliminary results.

Manuscripts under preparation (with tentative titles):

- From Unstructured Point Cloud to Computable Digital Twin: A Vision and Synthesis towards Civil Infrastructure Maintenance Automation. (Z. Q. Chen, P.-C. Chun, et al., targeted for ASCE Computing in Civil Engineering or ASCE OPEN Journal, 2026.)
- Quantum Computing for Resource Optimization in Mega-City Infrastructure Networks – A Vision. (Z. Q. Chen, P.-C. Chun, et al., targeted for Urban Lifeline, A Springer Nature Journal)

(3) その他/Remarks

特になし

(注) 採用期間終了後 3 ヶ月以内に提出

※ (Note) Submit the form within 3 months after the expiration of fellowship.

※ 様式 1 に記載された情報を基に確認しますので、部局名等の名称含め、内容に誤りが無いか必ずご確認ください。