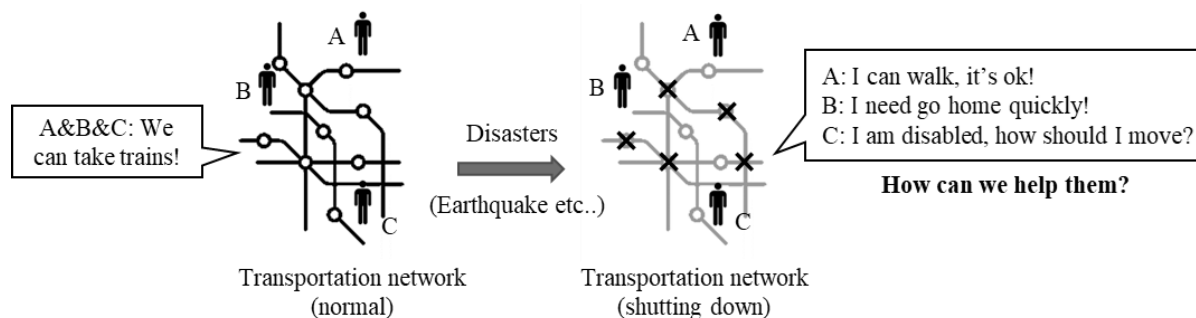> ２．【研究計画】適宜概念図を用いるなどして、わかりやすく記入してください。なお、本項目は１頁に収めてください。様式の変更・追加は不可。
>
> (1) 研究の位置づけ
>   特別研究員として取り組む研究の位置づけについて、当該分野の状況や課題等の背景、並びに本研究計画の着想に至った経緯も含めて記入してください。

● **当該分野の状況や課題等の背景**

Recently, artificial intelligence (**AI**) has been introduced to efficiently understand human mobility and optimize urban systems for disaster prevention(防災) **[1]**. Previous research focused on how to build a temporary communication network or collect data with remote sensing during disasters **[2]**. However, because of the bias in the population, **fairness** is still underdeveloped to ensure that disaster prevention issues can be solved in a low-sensitive way, which is also not taken seriously by current research. We know that the population in a city varies in many aspects, such as gender, age, and physical condition. If we try to help people with only one strategy, unfairness during disaster prevention will be inevitable. For general urban systems and services, previous research has explored how to reduce racial unfairness phenomenon based on demographic information **[3]**. Commercial systems such as ride-hailing services are also beginning to balance the drivers' utility and passengers' experience as much as possible **[4]**.

Transportation network (normal) → Disasters (Earthquake etc..) → Transportation network (shutting down)

A&B&C: We can take trains!

A: I can walk, it's ok!
B: I need go home quickly!
C: I am disabled, how should I move?

How can we help them?

When an unpredictable disaster occurs, the urban service, like the transportation system, can be severely impacted. During the Great East Japan Earthquake in 2011, many people in the Tokyo area could not return home because of the collapsed rail system and long-time road congestion, also known as the **Stranded Persons issue** (帰宅困難者). People's mobility demands change dynamically with time and location, which is a trigger for potential unfairness. Therefore, the applicant believes that **how to meet this spatial imbalance demands for disaster prevention is an essential application of disaster prevention AI**.

● **本研究計画の着想に至った経緯**

Applicants in the past have researched large-scale trajectory prediction methods for **Stranded Persons issues**. However, it is also important to consider the differences among people while solving large-scale urban problems during disasters. The applicant hopes to combine **AI fairness** with **disaster prevention systems** to support making relief decisions.

To fairly solve the issue illustrated in the figure, this proposal focuses on two main **key points**:

- How to discover fairness indicators that affect people's travel demands from big spatial data?
- How to model human mobility demands under disasters and provide decision support based on fairness indicators?

Based on the previous research experience and the situation of multi-hazards in Japan, this proposal combines knowledge from multiple fields, such as spatial information science and disaster prevention, to constitute a method for urban disaster relief strategies with AI fairness as the core principle.

Reference:
[1] Song, Xuan, et al. ACM TIST 8.2 (2016): 1-23.
[2] Song, Xuan, et al. IEEE Trans. Big Data 8.2 (2020): 397-419.
[3] Shaham, Sina, et al. PVLDB 16.2 (2022): 167-179.
[4] Sühr, Tom, et al. ACM SIGKDD, 2019.

　　申請者登録名　　　楊　暁杰

（2）研究目的・内容等

① 特別研究員として取り組む研究計画における研究目的、研究方法、研究内容について記入してください。
② どのような計画で、何を、どこまで明らかにしようとするのか、特別研究員奨励費の応募区分（下記（※）参照）に応じて、具体的に記入してください。
③ 研究の特色・独創的な点（先行研究等との比較、本研究の完成時に予想されるインパクト、将来の見通し等）にも触れて記入してください。
④ 研究計画が所属研究室としての研究活動の一部と位置づけられる場合は申請者が担当する部分を明らかにしてください。
⑤ 研究計画の期間中に受入研究機関と異なる研究機関（外国の研究機関等を含む。）において研究に従事することも計画している場合は、具体的に記入してください。
（※）特別研究員奨励費の研究期間が３年の場合の応募総額は（Ａ区分）が240万円以下、（Ｂ区分）が240万円超450万円以下（DC1のみ）。２年の場合は（Ａ区分）が160万円以下、（Ｂ区分）が160万円超300万円以下。１年の場合は（Ａ区分）が80万円以下、（Ｂ区分）が80万円超150万円以下。（Ｂ区分については研究計画上必要な場合のみ記入）

● **研究目的**

This research proposal aims to build a decision-support model to address AI fairness for disaster prevention. It takes the Stranded Persons issue (帰宅困難者) as a starting point, discovers the fairness indicators in human mobility through multiple historical data, and then provide solutions (e.g., how to assign officially organized shuttles) based on unsupervised deep learning method to counter with the shutting-down transportation system on these indicators when a disaster happens.

● **研究方法、研究内容**
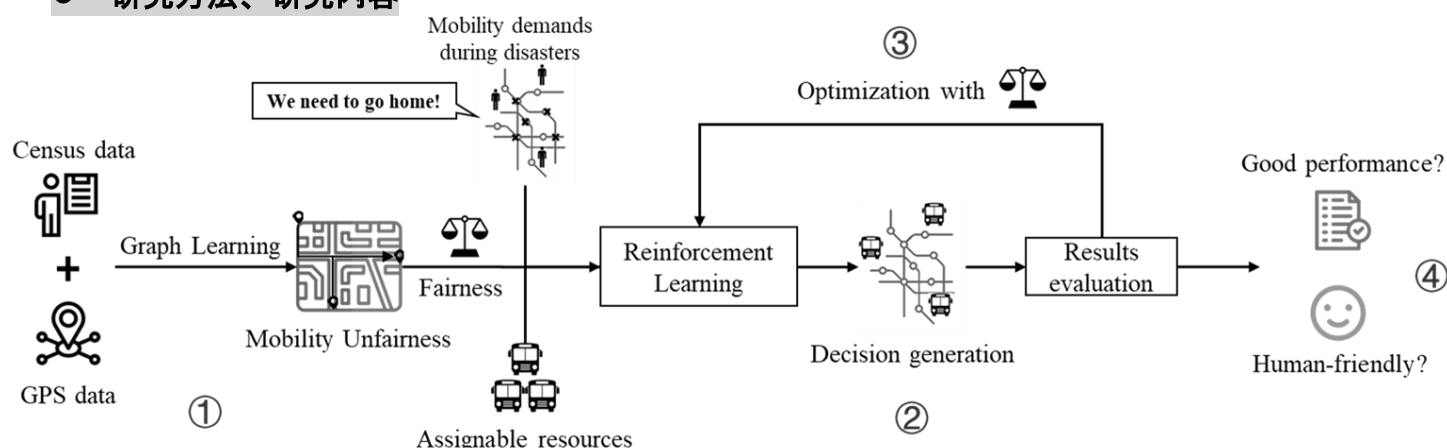
To address unfairness in disaster prevention, the central methodology of this research proposal is shown in the figure and explained as follows:

1. Define and mine fairness indicators. The proposal will combine multiple data, including GPS and census data, and investigation results of regional disaster prevention resources to find the unfairness (such as home locations and incomes) in human mobility with data mining methods such as graph learning [1, 2].

2. Establish a decision support model for disaster prevention. Based on the fairness indicators, the reinforcement learning model [1] will be introduced to generate a resource allocation decision (e.g., where the shuttles should be assigned). The study will combine a multi-objective optimization function [3] to design reward functions and train the model with a dynamic assignment mission with higher rewards.

3. Calculate the utility of the model output with fairness indicators. The model's utility will be judged at multiple time slices with designed metrics to show the balance of fairness. This step verifies the reasonableness of the indicators, helps us determine whether new unfairness arises, and optimize the model in the previous step.

4. Estimate model robustness based on ethical and social impact. The study will assess how effective and fair the generated decisions are at the data science and social levels and whether issues such as individual privacy are considered. Through this step, the research ensures that the above methods are effective and have contributed to solving social problems and reducing social conflicts.

● どのような計画で、何を、どこまで明らかにしようとするのか

Main Task	Sub Task	Year 1 2024 Apr.	Jul.	Oct.	2024 Jan.	Year 2 2025 Apr.	Jul.	Oct.	2026 Jan.
Part 1: Fairness definition and extraction	Data Collection								
	Fieldwork								
	Data Mining								
	1st Report(submit)								
Part 2: Decision support model construction	Model Construction								
Part 3: Model evaluation and detectoin of latend unfairness	Model Optimization								
	Evaluation and unfairness extracton								
	2nd Report(submit)								
Part 4: Assessment the social value of the research	Evaluation of social robustness								
	Final submissions								
				Milestone 1 1st research paper	Milestone 2 Model completed		Milestone 3 2nd research paper		Milestone 4 Human-Friendly AI

The schedule of this research is illustrated above. Based on the main tasks, the questions we wish to clarify are as follows: 1) The human mobility demands are related to fairness indicators such as the age-gender composition or regional average income with spatial distribution, and they also benefit decisions for disaster relief. 2) The constrained resource allocation decision with these indicators can be generated through a reinforcement learning model by dynamically multi-objective function optimization 3) Based on [3], fairness reward functions like a weighted sum of utility act as metrics to evaluate model output and help to discover latent unfairness. 4) Finally, the research combines the results of the field survey to evaluate the social robustness of the project and adjust our methodology based on human-friendly AI objectives.

● 研究の特色・独創的な点

本研究の特色: The innovation points of this research plan are mainly the following **two key points**.

1. The proposal is concerned with the microscopic individual-level bias. The applicant quantifies and engages the population differences in the decision-support process to solve social issues during disasters.

2. This proposal focuses on AI fairness, aiming to uncover core factors in urban human mobility. The interpretability for urban computing, systems, and services will be stronger than in previous research.

先行研究等との比較: Compared with previous research, the AI fairness-based disaster prevention model is a new application, and the decision for disaster scenarios supported by human mobility data do not exist.

予想されるインパクト、将来の見通し: The research can help to make decisions to support urban disaster prevention, so when the Stranded Persons issue occurs, policy-makers can arrange resources to help people get home. Simultaneously, the applicant believes the proposed model can be applied to other areas, such as allocating medical resources for infectious diseases and guiding people to urban shelters.

● 申請者が担当する部分

The applicant will undertake the main research content of **Part 1-3**. In studying the social impact in **Part 4,** the applicant will discuss and collect opinions with members of the Koshizuka Research Lab, to which he belongs. Also, regarding the views on fieldwork and Japanese society in **Part 1** and **Part 4**, the applicant plans to collaborate with Japanese students in the research lab with the supervisor's consent.

Reference:
[1] Hajian, Sara, Francesco Bonchi, and Carlos Castillo. "Algorithmic bias: From discrimination discovery to fairness-aware data mining." Proceedings of the 22nd ACM SIGKDD international conference on knowledge discovery and data mining. 2016.
[2] Kang, Jian, et al. "Inform: Individual fairness on graph mining." Proceedings of the 26th ACM SIGKDD international conference on knowledge discovery & data mining. 2020.
[3] Huang, Jianbin, et al. "Deep reinforcement learning-based trajectory pricing on ride-hailing platforms." ACM Transactions on Intelligent Systems and Technology (TIST) 13.3 (2022): 1-19.

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本欄には、「２．研究計画」を遂行するにあたって、相手方の同意・協力を必要とする研究、個人情報の取り扱いの配慮を必要とする研究、生命倫理・安全対策に対する取組を必要とする研究など指針・法令等（国際共同研究を行う国・地域の指針・法令等を含む）に基づく手続が必要な研究が含まれている場合、講じる対策と措置を記入してください。

例えば、個人情報を伴うアンケート調査・インタビュー調査、行動調査（個人履歴・映像を含む）、国内外の文化遺産の調査等、提供を受けた試料の使用、侵襲性を伴う研究、ヒト遺伝子解析研究、遺伝子組換え実験、動物実験など、研究機関内外の情報委員会や倫理委員会等における承認手続が必要となる調査・研究・実験などが対象となりますので手続の状況も具体的に記入してください。

なお、該当しない場合には、その旨記入してください。

● 人権の保護及び法令等の遵守への対応

This research's primary data source is <u>GPS location data</u> collected on personal mobile devices. The research process may involve contacting and communicating with relevant companies to purchase data or use public datasets. In either case, <u>personal information will be highly obscured and anonymized</u>. This research will comply with data management regulations and be published within controlled academic communication and publication limits. All data exchange and analysis actions regarding the research process will be conducted under the supervision of the supervisor to prevent data leakage or personal locating.

Also, this study will investigate the difference between disaster prevention and population movement among regions through some <u>survey results</u>. <u>The survey process will not involve personal privacy and confidential information.</u> Applicants will extract research-related content mainly through interviews with regional and relevant government personnel or through the compilation of publicly available data on the Internet.

⑴ 研究に関する自身の強み
Personal Strengths Regarding Research

● 主体性

I majored in **Geographic Information Science (GIS)** at the undergraduate level and gained some understanding of the potential of using spatial data to solve real-world problems. In the two years of my master's program at the University of Tokyo, I mainly utilized human mobility data from the **Great East Japan Earthquake (東日本大震災)** to extract the mobility patterns under different conditions and to make predictions for their movements using deep learning models. During this phase, I worked with another researcher in my lab to implement a real-time system for the **Tokyo Metropolitan Stranded Persons Project** (東京都帰宅困難者) to predict the future trajectory of crowds in the city using GPS data stream. We published the core part of this work in a paper at the International academic conference (**SIGSPATIAL 2022**). Now I also concentrate on **spatial data foundation and database** research and work for big spatial data to solve urban problems easily and quickly.

● 発想力、問題解決力

During my master's research, I tried to detect changes in crowd movement during normal conditions and disasters using multiple models. I experimented with **Mixture-Of-Experts models**, **meta-learning models**, and various mechanisms to implement a system framework that detects crowd movement anomalies due to earthquakes based on real-time GPS data streams and adjusts self-state autonomously. I also tried to generate trajectories of **interchange behavior(振替輸送)** due to the rail system shutdown at the end of the paper [1]. The abovementioned is where my imagination and problem-solving skills in disaster prevention AI-related implementations, system development, and urban computing knowledge are.

● 知識の幅・深さ、技量

In Spatial Information Science, it is very important to understand the relationship between people and the environment. It requires theoretical knowledge of geography, artificial intelligence, and the ability to interpret spatial phenomena and human behavior in context.

As an **undergraduate**, I learned map-related knowledge systematically and participated in the compilation of the Shenzhen Atlas (深セン市地図集). Also, I can use **C++** to build GIS visualization tools and web tools to deploy map **websites**. I have been involved in **satellite image processing** and related algorithm development to help develop a **meteorological remote sensing database**. I tried to use deep learning algorithms for the first time in my undergraduate thesis to build a traffic mode classification model for trajectory data using related tools from **MATLAB**. I was also at the top of my grade in terms of academic ability and won several school-level scholarships and one national-level scholarship. I can be recommended for graduate school exemption (大学院推薦資格) to my own University (Wuhan University) in my senior year.

During my master's degree, I came to Japan to study. During this time, I started working on using various spatial big data and began learning to analyze it using **Python** and related tools. During this period, I mainly used **Pytorch** to build deep-learning models. Meanwhile, while participating in the research lab project

mentioned above, I independently constructed a framework for processing real-time GPS data based on the **AWS** framework. I embedded the deep learning model for trajectory prediction. In my master's thesis, I focused on the framework of the urban trajectory prediction model based on **meta-learning theory** to achieve self-adaptation of the model to the city's current state.

Above, I have the expertise and ability to complete this research proposal.

● **コミュニケーション力・プレゼンテーション力**

I actively participate in the research lab group meetings and actively discuss urban computing topics with other researchers. Also, as a foreigner, I have good **Japanese** and **English** skills to help me communicate academically with experts. Last year, I traveled to Seattle, USA, to attend the academic conference (**SIGSPATIAL**), where I interacted with geoinformation scholars from around the world and learned a lot of advanced theories and knowledge. I actively participate in the internal presentation of the research office, and I am good at explaining the main points of the research in an easy-to-understand manner.

● **研究成果**

[1] Fan, Z., **Yang, X.**, Yuan, W., Jiang, R., Chen, Q., Song, X., & Shibasaki, R. (2022, November). Online trajectory prediction for metropolitan scale mobility digital twin. In Proceedings of the 30th International Conference on Advances in Geographic Information Systems (pp. 1-12).

1. I was responsible for part of the programming task and the evaluation of the **GRU-based trajectory prediction model.**

2. I was responsible for the algorithm of simulating the **interchange behavior** of the crowd during the rail system shutdown in the paper.

3. I built **a real-time trajectory prediction system** based on the main content of the thesis with a real-world AWS-based data stream to test its robustness.

(2) 今後研究者として更なる発展のため必要と考えている要素

Considered essential for further development as a researcher in the future

I need to focus and develop to improve my qualities as a researcher in four elements:

1. **The ability to communicate with experts from different professions**

   I have had many interactions with spatial information science and data science researchers, but I need more regarding the breadth of research. To complete this research project, I need to start interacting with researchers in **urban planning**, **disaster prevention**, and other related theories.

2. **The ability to present my research results in a more public situation**

   In the past, I mainly participated in presentations within my research lab. However, in the future, I need to improve my ability to present my research in public for academic research height, centered on my academic writing and academic publication skills.

3. **The ability to find innovative points of research in multiple domains**

   In the past, I was mainly concerned with implementing AI based on urban computing and did not explore the real-world applications of the research in depth. In the future, I want to combine theories and knowledge from multiple domains to apply data science to urban management problem-solving.

4. **The ability to develop deep learning / AI models independently**

   In the past, I have mainly focused on deep learning model development under guidance. In the future, I want to exercise my ability to understand the latest AI theories and deep learning frameworks on my own and use programming to embed them in my research.

５．【目指す研究者像等】各事項の字数制限はありませんが、全体で１頁に収めてください。様式の変更・追加は不可

　日本学術振興会特別研究員制度は、我が国の学術研究の将来を担う創造性に富んだ研究者の養成・確保に資することを目的としています。この目的に鑑み、(1)「目指す研究者像」、(2)「目指す研究者像に向けて特別研究員の採用期間中に行う研究活動の位置づけ」を記入してください。

(1)目指す研究者像 ※目指す研究者像に向けて身に付けるべき資質も含め記入してください。

I was deeply impressed by the 2008 Wenchuan earthquake in Sichuan, China, and the 2011 Great East Japan earthquake. As well as having spent four years in Wuhan, it is hard for me to forget the far-reaching suffering that infectious diseases of COVID-19 have brought to the world. If not handled well, I realized that such emergencies or disasters could bring significant loss to many people.

During my four years of undergraduate study at Wuhan University, I learned about mapping, computers, and other related fields. Although I was initially transferred to GIS because of my score, I also grew to like the subject. However, in the current era of big data, only by combining data science can we solve more and more complex problems.

Therefore, I came to Japan for my master's degree and joined the Shibasaki Research Lab of the Center for Spatial Information Science at the University of Tokyo. I gradually gained an in-depth understanding of what can be done with the contribution of big spatial data. As a result, I have learned a lot about urban computing and deep learning during my two-year master's degree and put much effort into its concrete application. Also, although there are many disasters in Japan, the government and researchers have established many coping strategies to deal with them, which is worth learning from a foreigner's perspective. At the Ph.D. level, after transferring to the Koshizuka Research Lab, I started to think about where I should work to apply my academic results to the real world. To this end, I began to care about spatial data foundations and database-related content and to think about how it can be combined with multi-disciplinary disciplines to solve real-life problems, such as disaster prevention.

As a Ph.D. student aiming to be a Research Fellowship, I want to construct a deep learning model with good performance and explore the potential value of my research to society by combining knowledge from multiple fields. I plan to have academic communications with researchers in data science and with researchers in sociology, psychology, and engineering to realize the contribution of big data to society. Also, through communication, I aim to improve my ability to express myself and communicate with people from different cultures. Finally, through my experience as a Research Fellowship, I will be able to apply the methods of academic foresight to my research and even to create value for society.

(2)上記の「目指す研究者像」に向けて、特別研究員の採用期間中に行う研究活動の位置づけ

By being selected as a Research Fellowship during my research activities, I hope to acquire the four qualities mentioned on the previous page and become a researcher who can contribute to solving social problems using data science research. To this end, I will publish my papers in international conferences or journals in conjunction with my research program and actively participate in research presentations at international conferences. To successfully realize the vision of this research proposal, I will actively interact with experts in the field of disaster prevention and conduct extensive field research to ensure the relevance of my research.

Based on the research activities, I will learn multi-disciplinary knowledge, apply data science theories and methods to social problems of urban disaster prevention, and become an interdisciplinary scholar to solve real-world problems, which is my research positioning for the adopted period as a Research Fellowship.