Personal Information

Application No. APL20240063	**Application Status** Pending
Full Name Mayank Pandey	**Email** mayankpandey@mnnit.ac.in
Phone Number 9935239332	**Date of Birth** 1976-07-02
Experience 22 years	**Core Competencies** Digital/ 3D Models, Edge computing devices, IoT, Sensors, Event, Geospatial Content Providers, Satellite imagery/ drones/ aerial, Geospatial digital twin content providers, Geospatial digital twin developers, Digital Elevation Model, Digital Terrain Model, Digital Scene Model, Others

Additional Information

Previous Experience in Related Projects

I acted as a Principal Investigator for the following projects which are aligned with the objectives envisaged for the "Digital Twin - Sangam" initiative: Project 1: Title: Testing and Evaluation of Crowd Management Strategies at Kumbh Mela Prayagraj using Agent Based Modelling and Simulation Details: Kumbh Mela, a festival of faith and belief is one among the many large gathering events around the world. Pilgrims arrive from different places to take a holy bath in the river Ganges. Police department is assigned a major role of handling and managing the crowd traffic in these events to avoid the occurrence of unwanted situations. In the recent Kumbh Mela held at Prayagraj from 15 January 2019 to 4 March 2019 (49 days), we were associated with the Kumbh Mela police administration under a project. The police authorities make crowd movement plans and different route diversion schemes to maintain crowd density at the site. The main surveillance points are the intersection zones and bathing areas at the bank of the river. The administration uses a wide range of technologies to manage each and every aspect of this big gathering. But, they don't have a technical way to analyze their movement plans. The project was intended to create an effective way, to assess the efficiency of their movement schemes with respect to time and density. This would help them to create better and effective movement schemes before actual deployment. Normally, the authoritative personnel plan different movement schemes on the basis of past experiences and discussions in the meetings. They deploy these schemes without any prior testing. Setting up the actual crowd gathering scenarios to test and analyze their plans is not feasible. Therefore, use of crowd simulation software tools would help to test, evaluate and assess the feasibility of their movement plans. In this work, a model is created utilizing a micro-modelling approach which incorporates the virtual environment (using GIS techniques) of Kumbh Mela site of Prayagraj, India. The model simulates different crowd movement plans and bathing procedures according to the real behavioral scenarios. The model is utilized to evaluate time consumed by the pilgrims to reach the bathing area and to count the number of pilgrims that took bath in 12 hours on different time intervals of the bathing procedure.Verified simulation results and validated outcomes established the applicability of this model. Project 2 Title: Evaluation of time consumption in the movement of a crowd of pilgrims from a particular place to another Details: Large gatherings in religious events like Kumbh Mela require rigorous monitoring and attention. Successful accomplishment of such an event involves stakeholders from different departments such as the Police department, department of traffic management, roadways, security, health department and many others. Railway department is one among them which plays a major role in the management of rail traffic and passenger transportation. In the Kumbh Mela held at Prayagraj from 15 January 2019 to 4 March 2019, we were associated with the Allahabad division of North Central Railway (NCR), India under a project. The railway authorities have an important role in the management of the crowd of pilgrims at the railway station during this Kumbh Mela festival. They predefine the crowd management plans,

movement strategies and boarding procedures. The project was intended to design an effective way to analyze and evaluate the time consumed in the movement of a crowd of pilgrims from a particular place to the assigned platform and board. This analysis was needed for adjusting the frequency of Mela special trains at various platforms and accordingly customizing their plans. We have utilized the Agent Based Modelling and Simulation technique to model the virtual environment of Allahabad Junction railway station. The model simulates various actions and behavior of synthetic agents (passengers and trains) according to the real scenarios. The model helped the authoritative personnel in testing their strategies for realistic assessments. The simulation results of time consumption in different movement and boarding scenarios is approximately similar to empirically evaluated values. The empirical values are shared by the railway authorities with us. In addition, some modified boarding procedures are incorporated to compare the efficiency of the actual plan executed by them.

Achievements or Recognitions
I have been felicitated by Kumbh Mela Administration and North Central Railway administration for my contributions during Kumbh Mela 2019. In addition to this, BBC Hindi news has recognized our efforts and we were able to publish some very good papers in reputed journals. The details are as follows: 1.Abha Trivedi, and Mayank Pandey. “Agent Based Modelling and Simulation to estimate movement time of pilgrims from one place to another at Allahabad Jn. Railway Station during Kumbh Mela-2019.” Autonomous Agents and Multi-Agent Systems 34, no. 1 (2020): 1-37 2.Anurag Pandey, Mayank Pandey, Navjot Singh, and Abha Trivedi. “KUMBH MELA: a case study for dense crowd counting and modeling.” Multimedia Tools and Applications (2020): 1-22 3.Abha Trivedi, and Mayank Pandey. “Testing and Evaluation of Crowd Management Strategies at Religious Gatherings in India using Agent Based Modelling and Simulation.” International Journal of Advanced Intelligence Paradigms, Inderscience, UK, DOI: 10.1504/IJAIP.2021.10025581 4.Trivedi, Abha, Mayank Pandey ,Ramesh, G. and Chhabra, Rohan. (2023). An agent based modeling approach to evaluate crowd movement strategies and density at bathing areas during Kumbh Mela-2019. Multimedia Tools and Applications. Vol 83. pg 1-39. 5.https://timesofindia.indiatimes.com/city/allahabad/software-to-help-cops-manage-crowd-atkumbh/articleshow/62609355.cms 6.https://www.facebook.com/BBCnewsHindi/videos/2077545762326722

Details of Submission

Title
Synergizing Geospatial Science, Computer Vision and Agent based Simulation to create near to real digital twins for Effective Crowd Management and Control for Large Religious gatherings in India.

Category
GIS, Computer Vision and Analysis, Simulation and Virtual Environment Support

Strategic Vision
Develop a digital twin (empowered by Agent based Modeling and Simulation) of the religious gathering venue that accurately replicates its physical layout, including structures, entrances, exits, routes, and surrounding infrastructure. Utilize high-resolution 3D modeling techniques to capture fine-grained details and spatial relationships, enabling realistic simulation and visualization of crowd dynamics. Establish interfaces for the digital twin to ingest information (by using computer vision techniques over historical and real time video feeds) such as crowd size, its density, behavioral pattern of pilgrims and their movement patterns. Geospatial data can complement this analysis by incorporating spatial context from maps, satellite imagery, and location-based inputs. This integration would enhance situational awareness and enable data-driven decision-making. The combined approach would facilitate optimized crowd management strategies, including crowd flow redirection, resource allocation, and identification of potential safety risks. Extend the digital twin framework with predictive modeling and simulation capabilities to forecast crowd behavior, anticipate congestion points, and evaluate the effectiveness of preemptive interventions.Integrate agent-based models, machine learning algorithms, and historical data analysis to simulate diverse scenarios and optimize crowd control strategies proactively.

Objectives
1. To investigate how the synergies between geospatial data science, agent-based modeling, and video analytics can be leveraged to enhance crowd management and control systems. This may involve integrating data from different sources, developing decision support systems, and implementing intelligent algorithms for

crowd prediction and control. 2. To design and implement a digital twin (using geospatial data science and agent based modeling) which can be used by the stakeholders to explore/measure the benefits and drawbacks of their crowd management and control strategies and optimize these before actual deployment. This simulation platform would be able to provide recommendations and guidelines to improve crowd management policies and planning. These recommendations may include infrastructure improvements, resource allocation strategies, route plans and operational protocols to enhance crowd safety, comfort, and overall experience. 3. To develop an interface for the synthetic agents of the digital twin to exhibit actual behavior of pilgrims in crowds. This can be done by using pre-trained machine learning models for prediction tasks or enabling agents to learn from real inputs coming from video analytics. 4. To regularly calibrate and validate the digital twin against real-world observations and ground truth data to ensure its accuracy and reliability. Incorporate feedback loops to iteratively improve the fidelity and performance of the digital twin over time, leveraging insights gained from actual event experiences and post-event analyses.

Alignment with Project Goals
The present proposal is completely aligned with the Digital-Twin Sangam project. It is a practical proposal which can assist the stakeholders towards planning of an event and accordingly designing the infrastructure. The core premise of the proposal is the adoption of a data-driven and unified approach which synergizes different bodies of knowledge (geospatial science, agent based modeling and simulation, machine learning and computer vision) to enhance decision making for finding efficient solutions towards infrastructure improvements, resource allocation strategies, and operational protocols.

Contribution to Project Goals
We will contribute towards the project goals by attempting to answer the following questions: 1. What are the trade-offs between accuracy and computational efficiency in implementing the agent-based model for large-scale crowd simulations in geospatial contexts, and how can these trade-offs be managed effectively? How much detailed (or abstracted) geospatial data is needed which can solve the purpose without losing on the important information. What are the appropriate methods for calibrating the agent-based model with observed crowd behavior data and geospatial information to ensure its accuracy and reliability? How can the agent-based model be validated using real-world data and geospatial analysis to assess its performance in reproducing crowd dynamics and informing crowd control strategies? 2. Generally, it is not computationally viable to simulate the entire geographical area of large-scale events like Prayagraj Kumbh (32 square kilometers with numerous entry/exit points in 2019). Therefore, it is required to develop the platform in segments where each segment is running parallel to each other (possibly on different CPUs) and interacting with each other to provide a synthesized simulation environment. How to achieve this?Most importantly, crowd influx is from different sources such as railway stations, bus stations etc. The crowd leaving from these places take different times to reach the actual event area depending upon the current crowd densities on the roads. How to incorporate this aspect parallelly in the simulation is an interesting issue.

Technological Resources

Category: Use Resource
Type of Resource: Software
Details: Anylogic Simulation Software
Specification: University Edition or Professional Edition AnyLogic 8.8.4-8.8.6
Purpose: For developing Agent based Simulation of pedestrians and integrating it with AI/ML interface and Digital Twin Interface
Alignment: Creating Digital Twin and Modeling and Simulation

Category: Use Resource
Type of Resource: Software
Details: ArcGIS
Specification: ArcGIS Enterprise 11.2
Purpose: For incorporating geospatial data in our model
Alignment: Creating Digital Twin and Modeling and Simulation

Human Resources Commitment

Human Category: Use Resource
Human Type of Resource: Expert
Human Details: Dinesh Kumar Azad, Director, Geohunt Solutions Pvt Ltd Add: GT Road (NH2), GANJKHWAJA, (RTO OFFICE STATION ROA), MUGHAL SARAI, CHANDAULI, UP 232120 IN Contact: 7905891080; azad.dinesh@gmail.com
Human Experience: 18 years in GIS softwares
Role: To Develop GIS models
Extent of Involvement:
Human Alignment: Creating Digital Twin with geospatial data

Human Category: Use Resource
Human Type of Resource: Expert
Human Details: Anurag Pandey Associate General Manager Engineering and RnD Services (ERS) HCLTech, Noida, +91-9910355331
Human Experience: 18 years in Computer Vision
Role: To use pre-trained machine learning models for prediction tasks and to enable synthetic agents to learn from real data
Extent of Involvement:
Human Alignment: Enabling synthetic agents with real behavior of pedestrians in religious crowds by performing video analytics over real video footage.

Human Category: Use Resource
Human Type of Resource: Expert
Human Details: Dr. Ramji Dwivedi, Associate Professor, GIS Cell, MNNIT Allahabad, Prayagraj, UP, India, CONTACT : ramjid@mnnit.ac.in ; +91-9454142973
Human Experience: 12 years in teaching and research in GIS
Role: To Develop GIS models
Extent of Involvement: Co-PI
Human Alignment: Creating Digital Twin with geospatial data

Human Category: Use Resource
Human Type of Resource: Expert
Human Details: Dr. Abha Trivedi, Assistant Professor, School of Computing Science and Engineering, VIT Bhopal
Human Experience: 10 years in ABM simulation, crowd modeling and simulation
Role: To develop ABM simulation platform
Extent of Involvement:
Human Alignment: Creating Digital Twin to facilitate crowd modeling and simulation

Other Information

1. As our research group is actively involved in solving similar problems, we are aware about the current state of the art. Further, due to our engagement (in the form of research and consultancy projects) with Kumbh Mela Police and North Central Railways in the previous Ardh-Kumbh 2019 held in Prayagraj, we have access to some invaluable video data captured using CCTVs and drone cameras. However, we do need to gather lots of relevant data, including geospatial data and crowd behavior data. This can include maps, satellite imagery, GIS layers, population density information, infrastructure details, and historical crowd movement patterns. 2. It is envisaged to develop an agent-based model to simulate crowd behavior based on the collected data and identified patterns from the geospatial analysis. This involves following steps: a) Define the agents (representing individuals or groups within the crowd), their behavior rules, and the environment within which they interact. b) Calibrate the model using observed data and validate it against real-world crowd dynamics. c) Conduct scenario

analysis using the developed models and methodologies to evaluate different crowd management strategies. Simulate various scenarios, such as changes in infrastructure, crowd control measures, or evacuation plans, and assess their impact on crowd behavior and management outcomes. d) Use performance metrics, such as crowd density, evacuation time, or safety indicators, to evaluate the effectiveness of the proposed strategies. By manipulating geospatial data and parameters within the ABM framework, different scenarios can be simulated to evaluate the effectiveness of various crowd control strategies. This includes testing the impact of different entrance or exit locations, placement of barriers, or changes in the built environment on crowd movement and congestion.

Certification

I declare that all the information given by me in this application and documents attached hereto are true to the best of my knowledge and that I have not willfully suppressed any material fact. I accept that if any of the information given by me in this application is in any way false or incorrect, my application may be rejected, any offer of the grant may be withdrawn or my candidature may be rejected at any time.