Oregon Department of Transportation

*Stage 1 Research Problem Statement*

**Number***: 25-11*

**Proposed Title: ExtremeWeatherGPT: Using Natural Language as Input for Highly Efficient Early Warning and Impact Simulation of Extreme Weather Events**

**1.** Concisely describe the **transportation issue** (including problems, improvements, or untested solutions) that Oregon needs to research.

Traditionally, detecting extreme weather conditions, issuing early warnings, and assessing their impacts across the entire state of Oregon require substantial technical expertise and time. The transportation system in Oregon faces escalating challenges due to climate change, including increased variability and more frequent and intense climate extremes, such as rising sea levels. Extreme weather events threaten the safety, mobility, and efficiency of the transportation system, disproportionately affecting disadvantaged communities. Given the national economic impacts of extreme weather—hurricanes ($529 billion), wildfires ($45.4 billion), floods ($1.023 billion), etc.—the adoption of advanced technologies for improved detection and management is crucial to protect our transportation infrastructure. With recent breakthroughs in artificial intelligence, particularly large language models (LLMs) like ChatGPT, there exists an opportunity to harness natural language processing to automatically detect extreme weather conditions and generate traffic simulations that assess their potential impacts. Bridging this gap could result in significant savings in terms of technical manpower and time for extreme weather monitoring and evaluation.

**2.** Document how this **transportation issue** is important to Oregon and will meet the Oregon Research Advisory Committee Priorities

The proposed project address multiple research focus areas of ODOT: 1) Safety; 2) Equity; 3) Climate; 3) Workforce development; and 4) Innovative technologies and systems. It also addresses multiple research outcome priorities: 1) Economic and community vitality; 2) Social equity; 3) Mobility; 4) Safety; and 5) Sustainability and Climate Action. The research will fit well into the Climate Action Plan 2021-2026, ODOT's 5-year plan for work to address the impacts of climate change and extreme weather on the transportation system in Oregon, by making the transportation system more resilient to extreme weather events.

Furthermore, the modern transportation workforce, diverse in age, experience, and background, demands training methods that are inclusive and adaptable. Maintaining up-to-date training resources and organizing regular sessions are both time-consuming and expensive, straining both budgetary and human resources. There is a clear need for a dynamic, adaptable, and engaging training solution to address these challenges effectively. Furthermore, with retirement of experienced traffic management professionals, there is an urgent need to retain their valuable hands-on experience and insights.

The project aims to innovate an integrated detection and simulation methodology using a finely tuned large language model (LLM), *ExtremeWeatherGPT*, designed to process multi-source data inputs in natural language for the early detection of extreme weather events. We will leverage this model to simulate the potential impacts on traffic and infrastructure within Oregon State DOT's jurisdiction, utilizing the open-source "Simulation of Urban MObility" (SUMO) traffic simulations.

**3.** What **final product or information** needs to be produced to enable this research to be implemented?

The proposed project will produce the following products that can be freely available to ODOT operations manager and operators and potentially to vulnerable communities, for near-real-time decision making, workforce training, as well as post-event debriefing and improvement:

- Development of an LLM-driven cutting-edge extreme weather early warning system tailored for multi-source data interpretation, potentially mitigating economic damages.
- Development of an LLM-driven method for simulation model generation and extreme weather scenario assessment.

- Data-driven mitigation strategies to lessen the financial impact on Oregon's transportation network due to extreme weather.

**4.** (Optional) Are there any individuals in Oregon who will be instrumental to the success of implementing any solution that is identified by this research? If so, please list them below.

| Name | Title | Email | Phone |
|---|---|---|---|
| Ron F. Curb | Senior Engineering Manager, ODOT | rcurb@odot.org | 405-420-9163 |
| Nathaniel Price | ITS Operations Engineer, FHWA | nathaniel.price@dot.gov | 503-316-2566 |
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**5.** Other comments:
This project is based on the most recent advances in artificial intelligence (AI). We are not aware of any similar research on the training of workforces using large language models, particularly in the context of resilient traffic operations in response to extreme weather events. The project ideas and tasks are built upon solid foundations from the Rensselaer Polytechnic Institute (RPI) and the Washington State University (WSU) – for example, the co-authored book "Machine Learning for Transportation Research and Applications" from Dr. Ruimin Ke published by Elsevier in 2023. Dr. Ke's research group at RPI and Dr. Shi's group at WSU have been implementing LLMs for intelligent transportation applications.

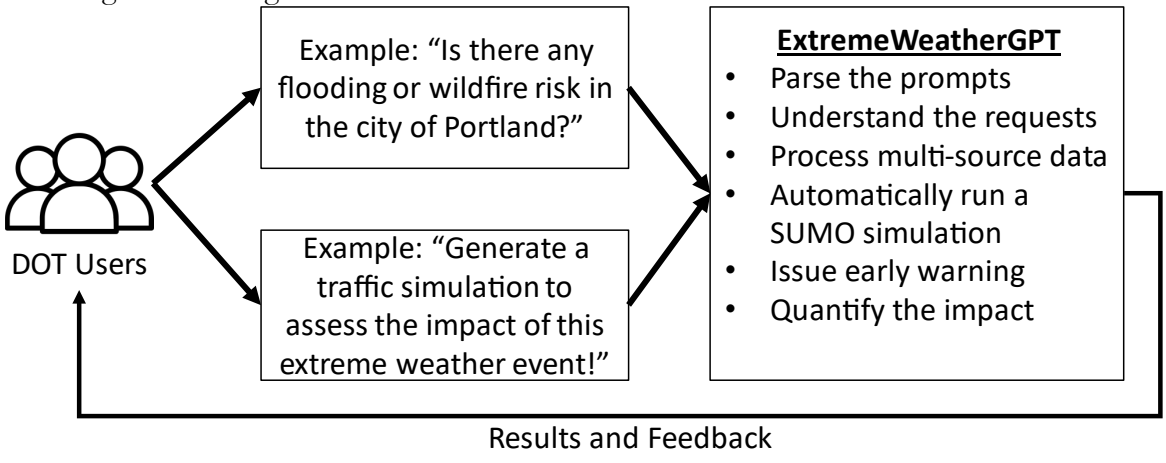
At this stage, we anticipate the following methodology to achieve the project goal and objectives:

1. Data Aggregation: Collect multi-modal data sources, including news, social media, and surveillance feeds, similar to historical precedents like Hurricane Katrina and the Camp Fire, for comprehensive analysis.
2. LLM Fine-Tuning: Customize ExtremeWeatherGPT to process and understand natural language inputs, e.g., "Is there any flooding risk in Portland?", from varied data sources, enabling the model to identify and predict potential extreme weather events effectively.
3. Simulation Integration: Employ natural language and processed insights from ExtremeWeatherGPT to drive SUMO traffic simulations, constructing scenarios reflective of the impacts from events. An example input is: "Generate a traffic simulation for Portland to assess the impact of wildfire A from last week!"
4. Economic Impact Analysis: Assess the potential economic ramifications on transportation infrastructure using insights gleaned from ExtremeWeatherGPT.

*Implications for Policy and Practice:*

- Establishment of policy guidelines for integrating AI technology in state disaster response and infrastructure resilience planning.
- A foundation for resource allocation decisions in disaster preparedness and recovery, anchored in economic data and predictive modeling.
- Enhanced transportation planning for Oregon, incorporating predictive analytics to prepare for and adapt to the increasing unpredictability of extreme weather patterns.

A flowchart showing the basic logic of ExtremeWeatherGPT is as follows:



**6.** Corresponding Submitter's Contact Information: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