Research Project Name: A Diffusion Model for Generating Safety-Critical Rural Driving Video Data
Recipient/Grant (Contract) Number: Florida A&M University; Stony Brook University
Center Name: Rural Safe Efficient Advanced Transportation (R-SEAT) Center
Research Priority: Improving Mobility of People and Goods
Principal Investigator(s): Ruwen Qin
Project Partners: -
Research Project Funding: $97,569 (Federal request); $50,000 (Non-Federal cost share)
Project Start and End Date: 6/1/2024 to 5/31/2025
Project Description: In the United States, about 20% of the population lives in rural areas covering 97% of the land. Due to the lower density of population in rural areas, auto, which consists of car, SUB, pickup truck, and rental car, is still the dominating transportation mode there. Statistics further shows that 40% of fatalities occurred in rural areas although only 31% of the total VMT there. Consequently, the fatalities rate per 100 million VMT in rural areas is 1.5 times of that in urban areas [4]. Addressing the traffic safety concern is among the required efforts to provide rural communities with access to resources via transportation. Autonomous vehicle technologies can be effective in reducing crash rates in rural areas, especially for vulnerable users such as senior drivers. In the current stage, level 2 self-driving technologies are becoming more mature and affordable than before, rapidly diffusing in the market. Level 2 self-driving vehicles are equipped with some Advanced Driving Assistance Systems (ADAS) that can control both the steering and acceleration/deceleration of vehicles, but drivers still need to remain engaged and be ready to take over the control at any time. Adaptive cruise control, lane keeping, and lane centering are representative ADAS features. Given that 66% of rural fatalities were in roadway-departure crashes, those ADAS features should be helpful in reducing fatalities in rural roads. Self-driving automobile manufacturers tend to prioritize densely populated urban centers where there is a higher demand for transportation solutions and greater potential for profitability. By targeting urban markets, car manufacturers aim to capitalize on the immediate and foreseeable opportunities presented by urban mobility needs. As the market is not oriented toward rural areas where only 20% of the population lives, Level-2 self-driving technologies are biased toward urban driving contexts, not sufficiently adapting to rural areas. For example, the perception module in ADAS is an integration of sensors and machine perception models. Training perception models require labeled sensory data about driving scenes. Acquiring training data about rural driving scenarios is an expensive investment, considering that 68% of the nation's lane-miles are in rural areas. With insufficient training data collected from rural areas, performance of Level-2 self-driving vehicles, such as safety, comfort, and energy efficiency, have not reached the satisfying levels there. How to obtain training and testing data about driving in rural areas in a cost-effective manner has been an urgent need for Level-2 self-driving technologies.

In this project, a machine learning model that can generate synthetic driving video data in a cost-effective manner for leveraging up the safety of Level-2 self-driving technologies in rural areas will be developed. Particularly, the project focuses on generating data of the driving environment where the imperfect natural environment and/or transportation infrastructure fail the current Level-2 systems. Examples of such driving scenarios include suddenly encountering fast-moving, wide animals or livestock at dawn and dusk, roads with deteriorated or temporarily removed/occluded lane markings, and others.
US DOT Priorities: This project aligns with the USDOT the strategic areas of Safety, and Transformation
Outputs: A new machine learning model that tailors ADAS for rural areas.
Outcomes/Impacts: Level-2 self-driving technologies that are equally beneficial and safe for rural residents.
Final Research Report: N/A