Scalable Modeling and Adaptive Real-time Trust-based Communication (SMARTc) System for Roadway Inundations in Flood-Prone Communities

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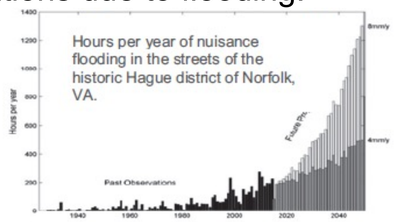
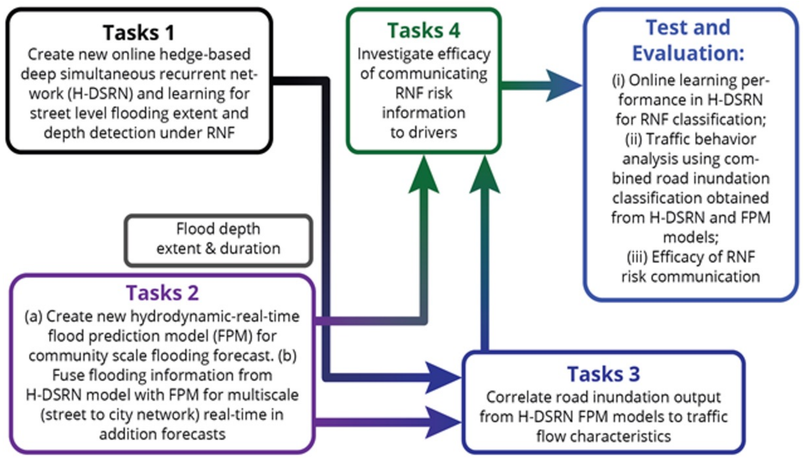
Project Challange

Recurrent flooding is expected to get worse due to sea lever rise, storm surge, and heavy rain.
There is no scalable and effective system to monitor and forecast road inundations due to flooding.



Project Goals

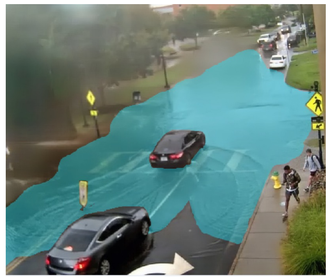
- Develop a Scalable Modeling and Adaptive Real-time Trust-based communication (SMARTc) system for roadway inundation detection and monitoring
- Evaluate the system for a flood-prone region in the City of Norfolk, VA using data from the City's cameras, tide gauges, and existing and new overland water level sensors in the field



Community Partners

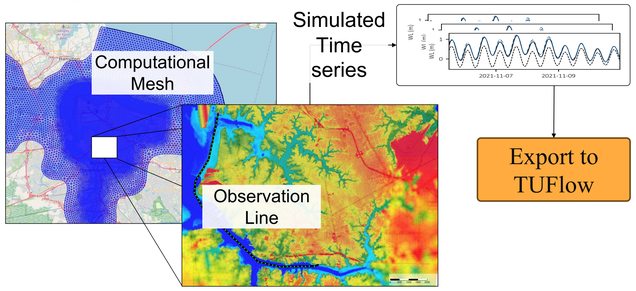
- City of Norfolk, VA
- RISE – nonprofit organization focused on community resiliency

Major Outcomes/Progress

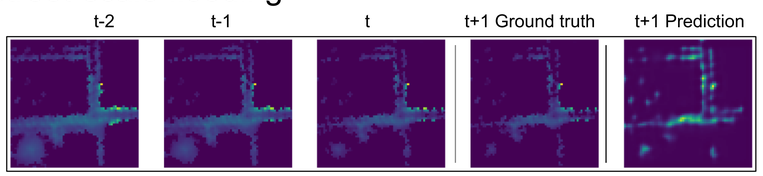


- Tested various Deep Learning (DL) models for segmenting images for detecting floodwater on roadways
- Created an ML pipeline to predict floodwater levels in relation to partially submerged vehicle images

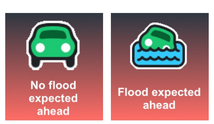
A **hydrodynamic model** was developed in Delft3D to simulate storm surge and provide boundary data for a hydrological model for inland flooding.



Using data from a physics-based model, convolutional LSTM (ConvLSTM) networks are trained to create surrogate models that require low runtime in comparison to physics-based models to forecast street-scale flooding



To examine the effects of flood warning type on perceived risk, and the actions taken by drivers 72 participants were hired to drive through different flood scenarios created in a driving simulator.



Participants' responses when faced with an 8-inch flood warning were equivalent to responses when no depth was specified in the flood warning.

Intellectual Merit

- Novel machine learning (ML) algorithms for detecting floodwater extent and depth in real-time based on surveillance camera images.
- A coupled hydrologic-stormwater-coastal model to predict flood levels at city network level and real-time update of these predictions based on sensor and image data.
- Prediction of roadway capacities in real-time under partial inundations and correlation of floodwater depth and extent with driver behavior.
- Effective communication of flood risk and road inundation to the public, leveraging granularity and uncertainty of flood information.

Broader Impacts

- New solutions for predicting flooding on city roads in real-time.
- Safer roads since drivers can use the information to avoid driving through flooded roads and emergency vehicles can reroute around inundated roads.
- A strong partnership with the City of Norfolk and RISE for evaluating the SMARTc system for a flood-prone region.
- Integration of research outcomes into undergraduate and graduate classes, hands on activities for visiting high school students, and interdisciplinary capstone projects.

Future Goals

- Further enhance the ML-pipelines for predicting flood depth and extent from image data
- Couple the flood inundation forecasting models with the ML-based storm surge model to improve the accuracy of forecasting compound floods.
- Calibrate car following models to simulate how drivers navigate through partially flooded road segments