Academic Advisors:
Dr. Dimitri Mavris &
Dr. Michael Balchanos

A Deep Learning Approach Using Social Media Data to Estimate Ground Risk of UAS in Urban Areas

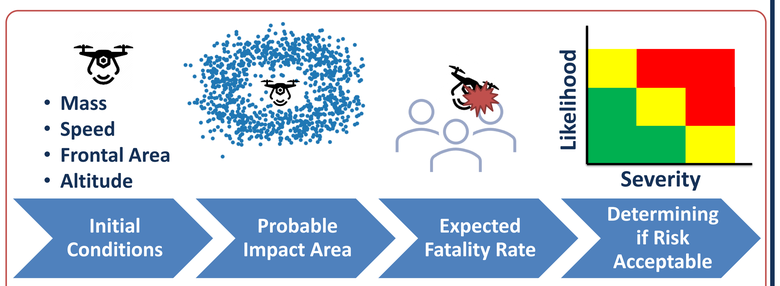
Jeffrey Pattison

Background

Unmanned Aerial Systems (UAS) are quickly becoming more common for a variety of applications. However, an increase of UAS in the National Airspace increases risk to other aircraft and to people on the ground. Safety concerns around UAS operating over people have limited UAS use, resulting in a need for risk assessment and mitigation techniques.

Problem and Motivation

Manned aircraft can typically rely on historical flight data for operational risk assessment. With UAS being relatively newer, UAS lack sufficient historical flight data for similar risk assessment, so physics-based modeling and simulation has become next best option.



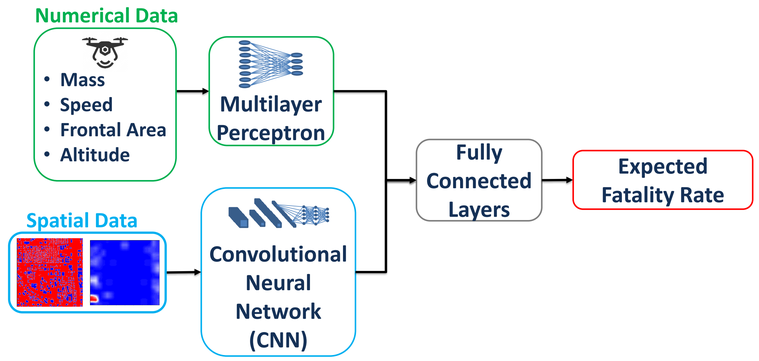
Common Physics-Based Process for UAS Ground Risk Assessment

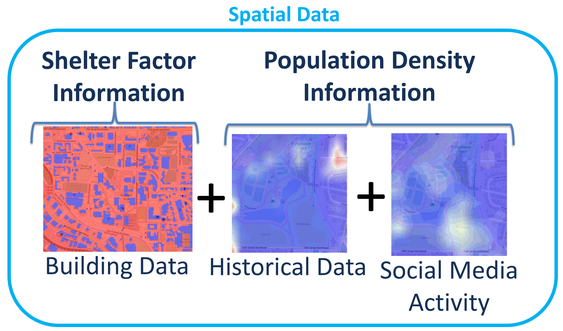
Common physics-based methods for ground risk assessment simulate a UAS descent trajectory and use the kinetic energy and location of impact to estimate an expected fatality rate based on population density and shelter factor. However, simulating the UAS descent trajectories is probabilistic to account for uncertainties in UAS characteristics, like position, velocity and drag. As a result, several descent trajectory simulations are required to find the probable impact locations of a UAS. This requires significant computation time, slowing down the risk assessment process. For urban areas that have a dynamic population, UAS risk assessment needs to be fast and accurate to keep up with the ever changing conditions.

Current probabilistic methods used for UAS ground risk assessment are insufficient because they are too computationally expensive

A Machine Learning Approach for UAS Risk Assessment

Machine learning methods can be used to approximate the computationally expensive physics-based models for risk assessment. The Machine Learning solution needs to be able to handle numerical data like UAS characteristics, but also spatial data like population density and shelter information. A Multilayer Perceptron can handle the numerical data while a Convolutional Neural Network can handle the spatial data, and the two can be combined to ultimately predict expected fatality rates.



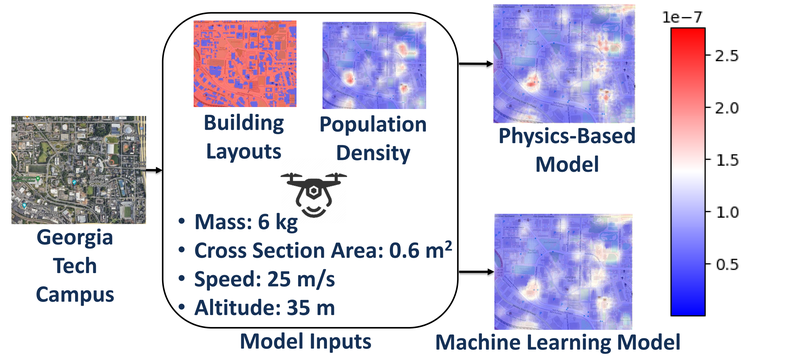


Training the Machine Learning Model

The Machine Learning model required data for training, so different combinations of UAS characteristics and spatial data were used as input to the physics-based model to generate training data. This process mapped the UAS characteristics and spatial data to expected fatality rates. A Machine Learning model was trained on this data using Mean Absolute Percent Error (MAPE) as a cost function. A summary of the training results are below:

Training Loss (MAPE)	Validation Loss (MAPE)
16%	22%

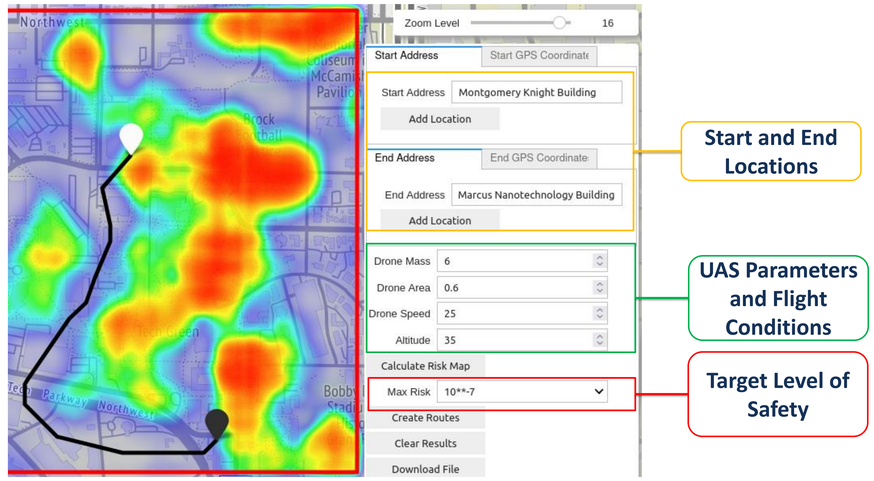
Comparing the Machine Learning Model to the Physics-Based Models for Risk Assessment



The Machine Learning model was able to produce the risk map with a Mean Absolute Percent Error of 19% compared to the physics-based results in a small fraction of the time

Using the Machine Learning Risk Assessment for Route Planning

The Machine Learning model enables rapid UAS ground risk estimation, allowing for easy integration into UAS flight planning. Below is a user interface where a pilot can enter in start and end locations, UAS characteristics and flight conditions, and the Machine Learning model creates a heat map of UAS ground risk. A user can then define a target level of safety, and the route planner returns a routing solution that does not surpass the target level of safety specified.



Predicted Mean Risk (fatalities/flight hour)	Actual Mean Risk (fatalities/flight hour)	MAPE(%)
1.72e-8	1.8e-8	4.19