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SHORELINE PROTECTION PLANNING AGAINST SEA-LEVEL RISE: A COMPUTATIONALLY FEASIBLE APPROACH

Daniel Sierra[1*], Samer M. Madanat[2]

[1]Tandon School of Engineering, New York University
6 MetroTech Center, Brooklyn, NY 11201, United States
daniel.sierra@nyu.edu

[2]Division of Engineering, New York University Abu Dhabi
Saadiyat Marina District, Abu Dhabi, United Arab Emirates
samer.madanat@nyu.edu

ABSTRACT

Sea level rise poses an imminent threat to coastal cities, including their traffic networks which are the backbones of urban areas. Protecting the shoreline with seawalls would prevent inundations from happening, but the cost of protecting the coastline of a whole city could prove prohibitive. As planners devise the most effective levee protection strategy to mitigate traffic disruptions, they may face a large number of possible scenarios which may become computationally infeasible to execute, as they require hydrodynamic and traffic simulations that take around a day each.

This paper presents two Genetic Algorithms that explore the full range of protection scenarios with a guided search, aiming to maximize benefits in terms of travel time savings. Each generation, the algorithms look for a combination of levees that fall within a specific length range and keeps the combination if the travel time savings increase. This is done by protecting one additional partition at a time. Additionally, with a certain mutation probability, another partition is protected instead of the one considered for that generation. Sometimes, after this mutation probability, the resulting protection scenario will have a protection length larger than the length range. This is the reason for two separate Genetic Algorithms, one of them removes a single levee to try to accommodate for the seawall resulting from the mutation probability, while the other algorithm removes more levees if necessary.

The travel time savings used in this research were generated semi-randomly within a logical range obtained from the results of previous research. The algorithm was evaluated varying the parameters of levee length range and mutation probability against a Pareto frontier obtained from the generated travel time savings.

The results show a remarkable performance while reducing the expected number of simulations to be run to a fraction of the total. Having the highest mutation probabilities provide the best performance, but at the same time require the most amount of simulations to evaluate the travel time savings. Also, the larger the levee range, the fewer the required simulations to be run. Overall, the benefit to cost ratio in terms of performance to simulations needed shows that the smaller the mutation probability and the longer the levee range the better. This proves to be a promising tool for planners of coastal cities that require to explore protection scenarios with computational budget constraints.