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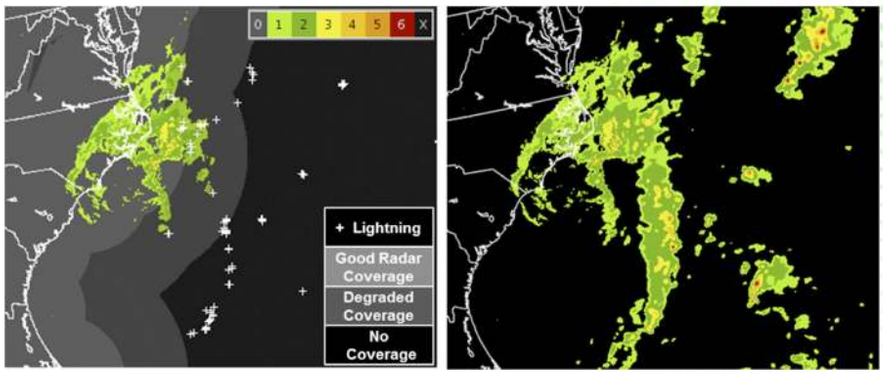
Creating Synthetic Radar Imagery Using Convolutional Neural Networks

Homeland Protection and Air Traffic Control | Lincoln Laboratory

Weather radar can track the location and intensity of storms and is useful for managing transportation around hazardous weather. Air traffic controllers, for example, rely on weather radar to track storms that could impact aircraft and flight schedules. Although land-based radar is sufficient to cover most continental air space, many offshore and oceanic controllers do not have sufficient access to the weather information that they need for proper air traffic management.

For this reason, a few years ago, staff from Air Traffic Control Systems, Group 43, developed the Offshore Precipitation Capability (OPC), a system that creates a radar-like depiction of precipitation—known as synthetic radar—by combining data from multiple nonradar sources. These nonradar sources include cloud-to-ground lightning flashes, geostationary satellite imagery, and numerical weather prediction models. This provides coverage in areas where there is no weather radar coverage.

Now, staff are taking this work one step further by implementing convolutional neural networks into the OPC system. Convolutional neural networks are useful in areas such as image recognition and classification. For OPC, they serve as a means of combining the nonradar data sources to create synthetic radar.



The figure on the left shows precipitation intensity, with lightning flashes as white plus symbols in the area outside the coverage of weather radar. By comparison, on the right are results from the Offshore Precipitation Capability's synthetic radar, which was created using convolutional neural networks and the methods described in this year's Laboratory Best Paper.

"Convolutional neural networks do not require hand-engineered weather features to train," said Christopher Mattioli, Group 43, regarding the benefit that convolutional neural networks bring to OPC. "They possess a unique ability to pick up on particular aspects of the weather scene that even the human eye can miss. On top of that, their ability to view disparate inputs as a single entity, all of which exist at different resolutions, is a key strength. This allows for a fusion of information, which ultimately informs the creation of the synthetic radar."

Mattioli and fellow staff recently published their paper "Creating Synthetic Radar Imagery Using Convolutional Neural Networks"

Creating Synthetic Radar Imagery Using Convolutional Neural Networks (continued)

in the Journal of Oceanic and Atmospheric Technology in December, and then received this year's Best Paper Award from the Laboratory. The Best Paper Award recognizes the authors of the most outstanding paper appearing in a peer-reviewed journal or peer-selected conference publication during an approximately one-year period preceding the award announcement.

"The capability described in this paper fills this gap [of coverage outside the range of land-based radar] by providing real-time radar-like analysis of current weather conditions in offshore regions using advanced machine learning methods," said Dr. Mark Veillette, Group 43, and lead author of the paper. "It was quickly adopted by the Federal Aviation Administration and air traffic community, and is now in the process of being acquired by the U.S. Air Force for global operations."

During the summer of 2017, a research prototype of the system was transitioned and demonstrated in five key air traffic control centers, including Miami, San Juan, Houston, New York City, and the Air Traffic Control System Command Center in Warrenton, Virginia. After the destruction of the weather radar on Puerto Rico by Hurricane Maria, OPC was used extensively by the National Weather Service office in San Juan. Thus far, the work has focused on generating synthetic radar over the Gulf of Mexico and the Caribbean Sea, but future steps will involve extending this capability to regions of the world without weather radar. Moving forward, advanced sensors and newly acquired training data will also lead to better model performance and greater coverage.

Eric Hassey, Group 43, said that the team behind the paper are grateful for the support they received from Laboratory groups, such as the Lincoln Laboratory Supercomputing Center, which helped make the analysis in the paper possible. "The team is thrilled and honored to receive the Laboratory's prestigious Best Paper Award," said Hassey. "Thank you to the selection committee for recognizing this work."

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