Tropical Cyclone Intensity Estimation Using Deep Convolutional Neural Networks

Manil Maskey, Dan Cecil, Rahul Ramachandran, J.J. Miller
NASA/MSFC

Estimating tropical cyclone intensity by just using satellite image is a challenging problem. With successful application of the Dvorak technique for more than 30 years along with some modifications and improvements, it is still used worldwide for tropical cyclone intensity estimation. A number of semi-automated techniques have been derived using the original Dvorak technique. However, these techniques suffer from subjective bias as evident from the most recent estimations on October 10, 2017 at 1500 UTC for Tropical Storm Ophelia: *The Dvorak intensity estimates ranged from T2.3/33 kt from UW-CIMSS to T3.0/45 kt from TAFB to T4.0/65 kt from SAB.* In this particular case, two human experts at TAFB and SAB differed by 20 kts in their Dvorak analyses, and the automated version at the University of Wisconsin was 12 kt lower than either of them. The National Hurricane Center (NHC) estimates about 10-20% uncertainty in its post analysis when only satellite based estimates are available.

The success of the Dvorak technique proves that spatial patterns in infrared (IR) imagery strongly relate to tropical cyclone intensity. This study aims to utilize deep learning, the current state of the art in pattern recognition and image recognition, to address the need for an automated and objective tropical cyclone intensity estimation. Deep learning is a multi-layer neural network consisting of several layers of simple computational units. It learns discriminative features without relying on a human expert to identify which features are important. Our study mainly focuses on convolutional neural network (CNN), a deep learning algorithm, to develop an objective tropical cyclone intensity estimation. CNN is a supervised learning algorithm requiring a large number of training data. Since the archives of intensity data and tropical cyclone centric satellite images are is openly available for use, the training data is easily created by combining the two. Results, case studies, prototypes, and advantages of this approach will be discussed.