Researchers develop method to assess damage from natural disasters

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Credit: Texas Tech University

Awesome. Amazing. Incredible. Unbelievable. Spectacular. These words aptly describe what is left following any natural disaster, whether it's an earthquake, tornado, hurricane or any other occurrence where homes, buildings or infrastructure are destroyed and lives are turned upside down.

However, these words are not the words the people whose lives have been permanently changed want to hear from anyone in their town assisting with the recovery efforts, or studying the effects of an event, not when it comes to discussing what is left of their homes and businesses, especially while piles of debris line the streets waiting to be cleared. Yet, as people begin to put their lives back together, the effects must be dealt with as well as those piles of debris.

Companies exist across the U.S. specializing in debris removal, and oftentimes, estimates of just how much debris there is to clear – and thus the amount those companies charge cities to clear it – is based on data provided solely by contractors.

Joseph Dannemiller, Larry Tanner and other researchers in the Debris Impact Facility at Texas Tech University are seeking to change the way volumes of debris are measured after a natural disaster.

Using drones and high-powered computers, Dannemiller, an instructor in the Edward E. Whitacre Jr. College of Engineering and a doctoral candidate in the National Wind Institute, and his colleagues have developed an information-based model to better analyze and estimate the volume of debris. This can cut down the expense to cities on how much it will cost to have all the debris cleared, potentially saving millions of dollars.

"We decided to develop a volumetric sampling-based model where we would fly over a region, estimate the volume of debris in that region, then fly a different region and estimate the volume of debris in that region," Dannemiller said. "Then, the industries that have grown up and now specialize in recovery could, through some central entity like the Federal Emergency Management Agency, be allocated to various disaster regions based on need. Right now, the decision of how assets are allocated is information-driven, but it is based on word of mouth or qualitative assessments."

Dannemiller and his colleagues put their theory and model to the test this summer after Hurricane Harvey decimated the Texas Gulf Coast. The researchers spent several days in the region gathering aerial imagery and footage they then brought back to Texas Tech. The imagery, footage and ground assessment data were used to create this information-based approach to determine the cost of debris removal.

Even though researchers had other opportunities previously, Harvey proved to be the perfect event to test their theories and practices.

"We've used these methods in the past but we've never used them for disaster recovery," Dannemiller said. "Harvey was the right event because it was local and provided us the opportunity to travel a short distance, gather a large amount of data and validate our methodology so we could move to the next phase."

Measuring the devastation

Flying over a region hit by a natural disaster is nothing new. The problem is that hiring a pilot to fly over numerous disaster regions to gather information can be expensive. Not only do you have to pay to hire the pilot, but there also is the cost for use of the aircraft, the fuel and the expensive photography equipment used to take pictures from 10,000 to 20,000 feet.

Additionally, manned flights are extremely time-consuming. A pilot can fly over a large region but the aircraft is expensive to maintain. It can add up to thousands of dollars per flight hour.

While they can't fly as large a region as manned aircraft, drones can make more flights in the same time using photography equipment that provides much more accurate assessments than imagery provided from manned aircraft. Drones can also fly under any cloud cover that obstructs regions being photographed during manned flights.

When using drones, the only cost encumbered by the city or recovery entity is the time and services of the pilot. Also, multiple drones can be flown at the same time by multiple pilots instead of being reliant on just one pilot or one plane.

Drones also allow researchers to take time-lapse measurements of areas to study how quickly and efficiently the debris is being removed and how quickly the region can recover after a month, six months, a year or longer. All in all, it's a method of debris measurement that is immensely more cost-effective and efficient than using word of mouth from the ground and manned aircraft in the sky.

With that impetus, Dannemiller and others made the trek to South Texas to put their theories to the test. The first task was getting permission.

Helping the recovery effort

"We already had connections with emergency and disaster managers," Dannemiller said. "All we had to do was figure out what the right region was to fly. We decided on three different cities. We went down there and drove the areas to determine which one of the three was the best."

The Texas Tech researchers chose those regions hardest hit by Harvey in terms of wind damage, not so much surge damage or flooding. Once there, the researchers contacted the proper authorities in each city to discuss their plans. If there was a concern from authorities or residents about the drones flying in a certain area, the research team simply would not fly that area. Most times, though, everyone was fine with what the researchers were doing.

"That is one of the things that is really surprising and welcoming after most disasters," Dannemiller said. "If you show you are generally there to help, to make things better, people are very accommodating, open, and even willing to help us gather what we need so we can let them get back to the business of putting their lives back together."

The researchers also flew temporary landfills where removal companies dump debris in order to build baselines for comparison. Removal companies base their charges to cities on debris volumes and the number of days it takes to remove those volumes. This information is then provided to the cities with little to no verification from any other entity. Drones can fly all of those sites in a single day and provide volumetric estimates – usually about 12,000-15,000 cubic meters, to within 20 cubic meters.

"So, now we can look at the errors associated with the qualitative approach, provide a sampling based quantitative alternative, and the city can decide what they want to do to maximize their recovery efforts, per dollar," Dannemiller said.

Developing the model

With the imagery, footage and information in hand, Dannemiller and his fellow researchers returned to Lubbock to begin developing the model. But processing six to eight football fields worth of area takes time, even for the most sophisticated computer programs.

The goal, ultimately, was to dial in on how much debris was created in order to develop the most accurate, information-based model for debris removal. Researchers were not concerned, at least at this point in the process, with delineating the types of debris, just the volume. That is for future research.

Credit: Texas Tech University

"The numbers contractors provide have not been verified up to this point, so no one knows how much debris was truly there," Dannemiller said. "It is hard to believe, but, from a scientific perspective no one has ever embarked on trying to measure or validate this information."

Dannemiller said the model also will help determine how many homes and businesses were affected, how much deforestation occurred, and how much infrastructure was damaged. Another advantage to the drone flights is their ability to take pictures at various angles, providing a three-dimensional (3-D) perspective that exceeds the information provided by the traditional overhead pictures taken by manned aircraft that only look top down.

He said that with their model, they can begin giving debris regional volumetric estimates within two days.

"What we offer that a manned flight cannot is a 3-D model so disaster managers and city planners can assess the region from a different perspective, and anyone can look at where the debris is concentrated," Dannemiller said. "Near the coast you have a lot of structures that are built up, and debris gets caught underneath. A flight that goes straight overhead and points straight down can't see that, but we can. So, now, disaster managers can make decisions based on a three-dimensional perspective of whatever they ask need."

Eventually, Dannemiller said, the model will be available for every type of natural disaster, from hurricanes to tornadoes to wildfires, and any sort of naturally occurring wind event.

But the usefulness of the models and the drone flights won't stop there. While it's good to give cities and contractors more accurate estimates of the volume of debris, there is little like being able to view the devastation firsthand.

That is why Dannemiller and his fellow researchers are now developing a virtual reality environment using the same 3-D models, which would allow people to walk around in a disaster region to understand the extent of the damage beyond just pictures and video from television reports.

As an example, he said the team could map an area the size of the Texas Tech campus and develop the 3-D virtual reality model in about three days.

"Every building in the virtual environment would look like the actual building," Dannemiller said. "You would see the same trees, the benches, the parks, the monuments, the statues, the flagpoles. We aim to make it so people can walk through that world, and see the extent of the devastation."

Being able to see that devastation would not only give disaster planners a way to view debris, but it also would help them understand the totality of the disaster before they get there, so they are prepared and can offer assurances to families and business and avoid some of the colorful descriptions that tend to discourage those trying to pick up their lives in the wake.

Finally, a 3-D virtual reality model would be useful to policy makers and government agencies to show them not only the breadth of the destruction but, also, with subsequent flights, how quickly an area is recovering from the disaster.

"It is important to understand the societal and economic repercussions of pouring all this money into relief efforts. Where the money goes and where the people go is a very important part of understanding how we as a society should respond," Dannemiller said.

"We aim to deliver an educational tool that allows people with to learn from these disasters so everyone, be they policy makers, first responders, city personnel, government employees or any member of the public simply willing to help, can see what the devastation is like before they arrive and can then focus their efforts on supporting the people and helping them rebuild."

Provided by Texas Tech University