CRISIS | RESPONSE

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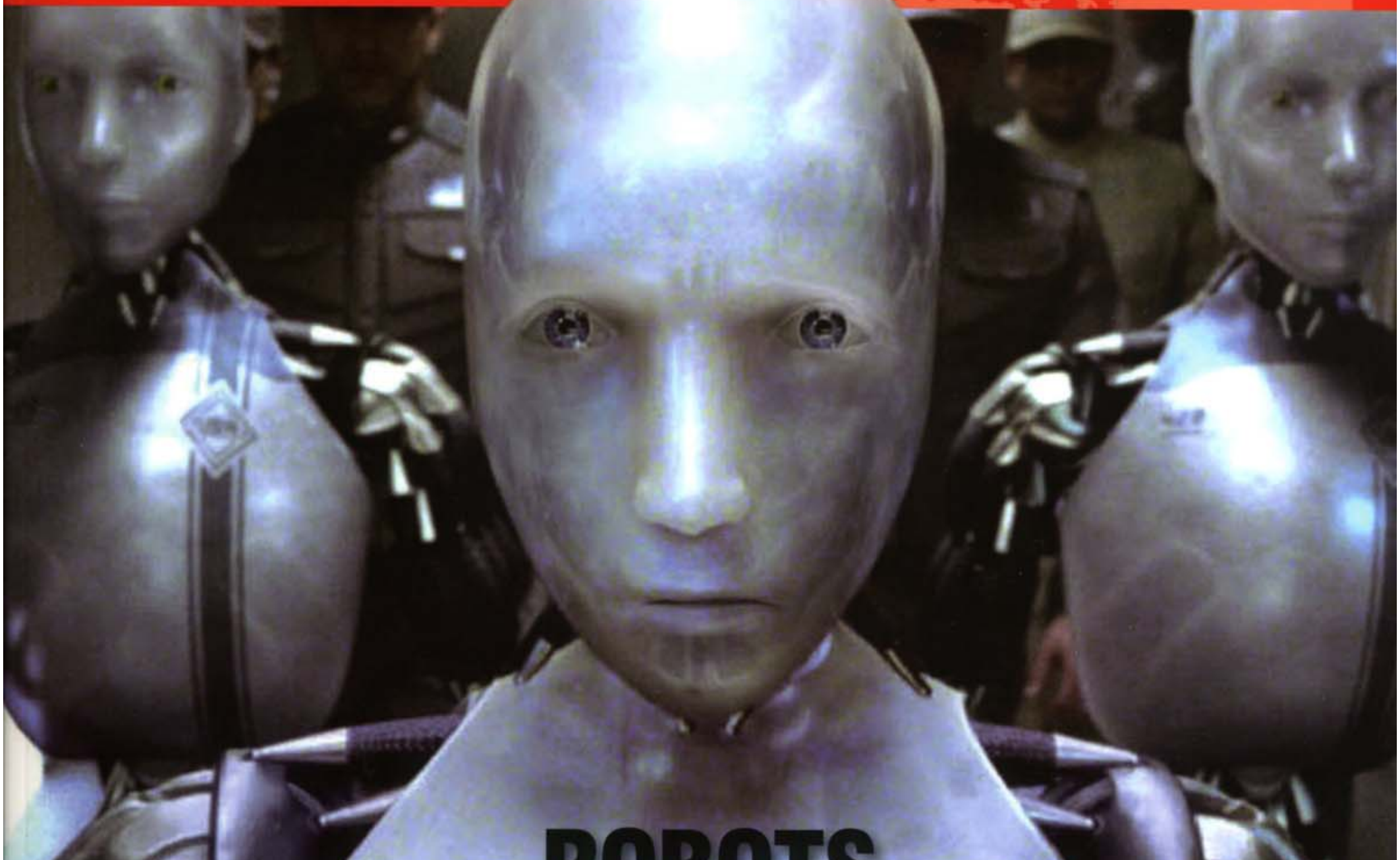

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Rescuers are one step closer to being able to use robots to help in disasters, says **Elena Messina**, and despite still having many limitations, robots can play a significant role in operations, particularly search and rescue scenarios

Robots to the rescue

IMAGINE FIRST RESPONDERS AT emergencies having an array of tools to help them assess a situation, search for survivors and monitor the environment to determine if it is safe for a responder to rescue a victim, or whether they need to send in a robot to save a life.

Popular cultural images (eg the *Terminator* movies) give the impression that robots which can operate independently, walking about easily and conversing with humans, exist already or are on the horizon. Tremendous strides have been made in the field of robotics recently but, for the foreseeable future, robots still have many limitations and will continue to require humans to control their operation. Despite limitations, however, robots can play a significant role in helping the response community by being the eyes and ears of rescuers in dangerous, unknown, or difficult-to-access locations.

First line of defence

In 2004, the US Department of Homeland Security (DHS) asked the National Institute of Standards and Technology (NIST) to lead an effort to develop performance standards for robots that could assist responders in searching for victims after a major disaster, such as a building collapse or a hurricane. NIST was chosen for its history of developing objective performance measures and for its foundational work on advanced robotics technologies. The DHS/NIST project seeks to aim technological progress in ways that expand robot capabilities for the benefit of emergency response applications. NIST has organised meetings to determine what responders need, conducted tests to improve robots and works with groups to set standards so that soon rescue robots will be the first line of defence in an emergency situation.

The standards under this project are being developed through a task group within ASTM International's Homeland Security Committee's Operational Equipment Subcommittee (E54.08). All standards being developed are based on requirements that members of the Federal Emergency Management Agency (FEMA) Urban Search and Rescue (USAR) Task Forces defined through a series of workshops hosted by NIST. The workshops yielded an initial set of over 100 requirements, which were grouped by technology areas, including: Mobility; communication; human-system interaction; sensing; logistics; and energy. The responder requirements included how they would be evaluated, what the metrics should be, as well as objective and threshold levels of performance. The requirements were defined by teams that confront the most formidable disasters, but the results are intended to be useful to the entire range of the response community, from local departments upwards.

A Northrop Grumman Remotec robot prepares to enter a passenger train to search for victims during an exercise at Disaster City, hosted by FEMA's Texas TF-1

National Institute of Standards & Technology

This standardisation project is unusual because responders do not currently use robots, so there are no well-defined concepts of operation. Further complicating matters is the vast range of response scenarios in which robots could potentially be deployed.

During the requirements-definition workshops, responders enumerated over a dozen deployment situations where robots could be useful. These ranged from very small robots that could be thrown into a confined space, to large, fast ones that can get downrange very quickly, carrying a complement of Chemical, Biological, Radiological, Nuclear and Explosive (CBRN-E) sensors to aerial and aquatic platforms. Complementing the standards definition process is a series of field exercises in which FEMA USAR Task Force members deploy robots at FEMA training sites. These exercises allow responders to explore the potential of robots, understand their strengths and limitations, further refine their performance expectations and requirements and develop concepts of operation.

Robot developers benefit greatly from the events as well. They are exposed to a new application domain and gain an understanding first hand of what responders' needs are. Exercises have been held at training facilities run by Nevada Task Force 1, Maryland Task Force 1, and multiple times at Disaster City, which is run by Texas Task Force 1.

At the response robot exercises, test methods are tried out by the robot developers and the responders. Both groups provide valuable feedback. A panoply of robots participate in the exercises. To date, over 60 different models of robots – wall-climbers, ground, aerial, and underwater – have attended the exercises.

The diversity of robots serves to underscore the range of operational roles that robots will play. Small aerial robots may be used to provide a broad oversight of the disaster and relay back to the incident commander information about how easy roads are to traverse, or areas that should be searched first. Larger ground robots can carry smaller ones, as well as HazMat sensors, deep into the disaster zone, keeping responders out until the hazards have been assessed. As they explore the area, the large robots can deploy the smaller ones along the way to crawl into voids and other spaces and search for victims.

Currently, robots are envisioned as providing the most assistance in the search phase but, eventually, they will be able to provide shoring capabilities and even transport victims out.

Because the robots will need such a wide spectrum of capabilities, the test methods under development emphasise quantifying performance of a particular capability along this spectrum and are not typically 'pass/fail'.

The performance required will depend on the role a search team would want the robot to play. For instance, one of the test methods that has become a standard is used to evaluate the visual acuity of the robot. Typically, the robot is controlled remotely by an operator who uses a control station that displays views of what the robot's onboard cameras see. In this test, the operator sits in front of the control station and sees a view of standard eye charts relayed back from the robot's camera. The smallest line that she or he can read successfully is used to define the robot system's visual acuity. The test covers both near-field and far-field vision and is conducted under different lighting conditions, including darkness. For a robot that is to assist in evaluating structural stability, being able to see very small features, perhaps at a distance (eg examining a crack from ceiling to floor level) with no ambient lighting, is crucial. So if making a purchasing decision, a task force that will use the robot to assist the structural engineer will expect very high far-field visual acuity under darkness. On the other hand, if a robot is expected to be used primarily to transport lumber or victims along a roadway, the visual acuity requirements would not be as stringent.

Other test methods are under development to measure the maximum distance at which a robot can effectively be controlled wirelessly, which is a major concern for remotely operated robots. There are limitations in the range of most communication systems, especially in and around buildings. Methods are under development for measuring the line of sight and beyond line of sight distance that a robot can receive commands and transmit video.

Until now there has been no means of measuring whether robots can even meet their manufacturer's specifications. Responders need to have confidence that they will be able to drive a robot into a disaster and not lose communication with it.

Standards have also been approved on terminology and for the impact that a robot would have on the team's deployment logistics. The logistics evaluation measures the additional volume and weight added to the response cache, tool requirements in case repairs are needed, and set up time to deployment once on site. Other near-term performance measurements that are being developed address the power requirements (measuring the battery life), mobility over a range of terrain types, situational awareness when navigating an unknown environment, audio capabilities (can the robot's onboard microphone assist in locating victims?), and the manipulation capabilities of the robot (eg using its arm and a gripper to open doors or aim a sensor through a small hole). In all of these areas, the challenge that NIST and its partners in the standards process face is abstracting real-world complexities into simplified, repeatable, and easily reproducible test procedures and supporting artefacts.

> "Robots still have many limitations and will continue to require humans to control their operation"

Assistive autonomy

Looking further into the future, robots will adopt more advanced capabilities, including producing maps of their environment as they explore, and assistive autonomy features, such as navigating portions of their route independently. NIST has been infusing some of these more futuristic capabilities into the project, by featuring selected ones at the response robot exercises. Responders look forward to being able to send a robot into a smoke-filled dangerous and unknown environment to create an initial map of the area, with possible victim locations noted. The responders could then use their expertise to plan a rescue strategy within the resulting map, hopefully saving time and minimising unnecessary risks.

There has been much progress in the capabilities of robots since the USAR robot standards project began in 2004. The standard test methods are setting concrete performance targets for the researchers and developers, helping them to direct their creativity and accelerate progress towards appropriate goals. CRJ

A Dragon Runner by Foster-Miller/Automatika explores a rubble pile at the Montgomery County Fire Rescue Training Academy, home of FEMA's Maryland Task Force 1. In the background, part of a Boz1, from BOZ Robotics, can be seen

Raymond Sheh

A Foster-Miller Talon robot is used to survey a wide-scale simulated disaster scene at Disaster City

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A Mesa-Matilda robot in action. To date, over 60 different models of robots have attended the exercises

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