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Swarms of robots join the army

Intelligent swarms of autonomous robots that look like insects could soon be deployed for military information-gathering and reconnaissance, says David Hambling

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Stehen Crampton of Swarm Systems. Photograph: Allan House/MoD

Small robots working in swarms have finally moved out of the laboratory and into the real world. That was the most significant feature of the Ministry of Defence's Grand Challenge competition, held over the weekend. It's an idea that is also being pursued by the US military.

The advantages of a decentralised swarm have long been apparent to researchers. After all, it's a strategy that has proven effective for ants, bees and other social insects for millions of years. However, until now, robot swarms have been experimental rather than practical.

Flying robots

The Grand Challenge took place at the MoD's urban combat training village on Salisbury Plain, and for the event it was bristling with threats - including hidden snipers and roadside bombs. Eleven teams competed in trying to locate the threats using robotic systems.

Several of the teams used robots working together and at least three could be classed as true swarms. Mindsheet fielded a fleet of mini-buggies and Locust a squadron of flying robots. Swarm Systems Ltd deployed a flock of eight small quad-rotor helicopters, called Owls.

"The principle advantage is robustness," says Stephen Crampton of Swarm Systems. "If eight vehicles go out and two are lost, then the other six can reform to carry out the whole task." Robustness is vital when otherwise the mission might fail because of a breakdown or accident. In a hazardous military situation, the system must be able to absorb damage. Additionally, multiple small units are cheap and easy to replace. They can also cover an area quickly and reduce mission time.

The Swarm Systems team was assisted by Professor Owen Holland of the University of Essex. Holland has previously worked on the idea of an UltraSwarm, described as a flying cluster computer in which multiple units combine their computing power. The Owls each have a spare processor, so they could be integrated into an UltraSwarm capable of processing data collected by swarm members. For example, it could map the dispersal pattern of airborne pollutants, allowing the swarm to follow them back to their source.

In the next year the Owls will also have a flocking algorithm. Researchers have found that birds use surprisingly simple rules in order to maintain their formation, and this technique has already been tested for parachute supply drops by US company Atair Aerospace. Its Onyx precision airdrop system allows GPS-guided aerofoil parachutes to fly together to the same spot without colliding. The same type of algorithm would allow a large number of Owls to operate autonomously in the same airspace.

Crampton says that a commercial version of the Owl swarm will be marketed next year. The possible applications include the military as well as police work, environmental monitoring and emergency search and rescue.

As might be expected, the US military is investing heavily in swarming robots, including the US army's Micro Autonomous Systems and Technology (Mast) programme. BAE Systems won a $38m (£20m) contract this year to lead an alliance of researchers from industry, academia and the military. Mast aims to provide a soldier with a swarm of insect-sized robots that can operate with "little or no direct human supervision" and provide intelligence about what is waiting around the corner or inside buildings. "The aim is to have a group of dissimilar robots working co-operatively," explains Aaron Penkacik of Advanced System.

One artist's impression released by BAE looks like a dragonfly, left; another is a spider-like robot, above. Each would have different roles, says Penkacik. The spider would be cheap and expendable, able to crawl through narrow openings and climb walls. When the spiders detect something of interest (such as a person), a dragonfly would be summoned to investigate with a video camera. The dragonflies, more expensive and capable, would be re-usable.

Other robots would be included depending on the task. Specialised units could be capable of sniffing out chemicals, radiation or explosives, or intercepting and locating radio communications.

Heart and node

The heart of the Mast architecture is Decentralised Data Fusion. Each robot is a node which only exchanges information with adjacent nodes. A node processes its own sensory data and combines it with incoming data to produce useful information, which is then shared with its neighbours. Any piece of information is only sent once, minimising the bandwidth needed. This scheme has no centralised data processing. The network is infinitely scaleable, and as Penkacik points out, if units are lost the network is self-healing.

Mast aims to advance the technology in this area rather than to develop a finished product. However, the growth in unmanned systems has been rapid, with the US military's force of airborne robots increasing from just 167 in 2002 to more than 3,000 today. Swarming robots look like a natural fit for tactical reconnaissance needs and are likely to be adopted swiftly.

The Grand Challenge demonstrated what swarms of small, low-cost units can already achieve. "The UK defence industry now has a new capability that can be taken to the front line," says Crampton. "In just over five years, the swarms of robots in the British armed forces will outnumber the soldiers."

Grand Challenge results

Overall Winner, awarded the R J Mitchell Trophy for Innovation
Team Stellar

Additional awards for technical excellence or innovation

Most innovative solution
Team Swarm

Best use of autonomy
Team Mira

Best systems integration
No winner

Judges' merit award
Team Cortex

Most imaginative use of national talent
Team Thales

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