by Jana Witt

"SWARMANOIDS" TO THE RESCUE!

New eyes, ears and hands for disaster zones

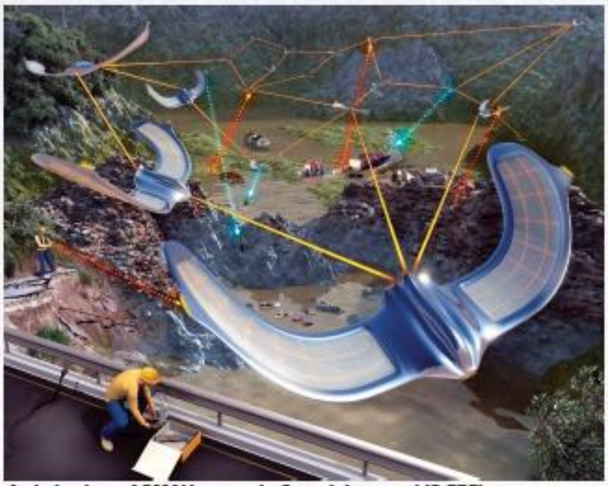
Researchers Severin Leven and Sabine Hauret fieldtesting the SMAV robots.

On 11 September 2001, only hours after the attack on the World Trade Center, a group of researchers from various universities arrived at the scene armed with several rescue robots. Among the debris, they aimed to search for victims in places that no human or rescue dog could reach; but when they entered the collapsed buildings, the robots fell short of expectations.

One of the main problems encountered on 11 September 2001 was that rescuers, researchers and robots were using the same General System for Mobile communications (GSM) as the many citizens of New York City, who were trying to get in touch with their relatives and friends. The GSM system was hopelessly overloaded, connections between researchers and their robots were noisy and often missing completely and communication between rescuers, researchers and robots was unreliable.

SWARMING MICRO AIR VEHICLES

Nine years after the attack on the World Trade Center, a group of researchers at the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland, working under Professor Dario Floreano is nearing the end of a project that aims to solve the problem of communication among rescuers. The researchers at the Laboratory for Intelligent Systems have been working on groups of flying robots called SMAVs (Swarming Micro Air Vehicles), to be deployed in disaster situations, such as 9/11 or the more recent earthquake in Haiti.



Artistic view of SMAV network. Copyright 2007 LIS EPFL.

"When there is a catastrophic situation the first thing to do is to establish a local radio network that the rescuers can use to communicate." explained Professor Floreano, "Establishing such a radio network takes time, needs specialists and is not always possible."

The researchers have found a compelling solution: using swarms of flying robots to create emergency wireless networks, when public communication networks are overloaded, damaged or non-existent. SMAVs are designed to be autonomous and carry a Linux system for navigation and swarming and an autopilot for flight stabilization. Pressure sensors relay altitude and speed information and a 3-cell LiPo battery supplies enough energy for one robot to fly for 30 minutes, before it has to return to base.

SMAV NETWORK

Hidden in the wing of the robot is a standard WiFi module which allows creation of a SMAV network (SMAVNET) between the robots themselves and the rescuers on the ground. SMAVNETs use a frequency which is not used by any other communication device and will therefore be more reliable than standard GSM networks.

"It is very difficult to control large groups of robots, so we took inspiration from what ants do and tried to apply it to our controllers." said Sabine Hauert, one of the PhD students working on the project, "The ants create chemical pathways between a food source and their nest, and we create communication pathways between different rescuers."

COMMUNICATION SPHERES

Each robot generates a communication sphere of around 100 metres. A line of ten robots could therefore create a communication line of approximately 1.5 kilometres, or cover an area of 300x300 square metres. Robots will detect rescuers and follow them, as if they were on an invisible leash, so the shape of the network will depend on the distribution of rescuers on the ground.

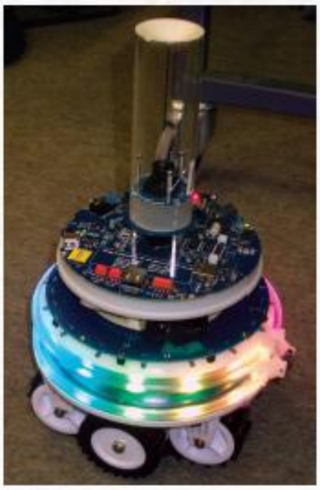
"Currently nobody has had more than five robots in the air yet." said Professor Floreano, but by August this year, when the project comes to an end, he hopes to have at least ten robots flying simultaneously. Wireless communication networks created by SMAVs are not that far from reality and could be rolled out within five years, according to Professor Floreano. "The foundations for artificial intelligence needed in swarms of robots are there. They are not yet ready, but they are there. The time to make a product, if there is a need and an advantage, would be relatively quick."

Clockwise from above left: current model of flying robot SMAV. Severin Leven replacing the battery on one of the SMAV robots. Inset: SMAV control box Linux board on right, autopilot on left and battery in front for easy replacement. Current prototype of the Eye-bot.

GROUND BOT CHALLENGES

In contrast to SMAVs and even though the first ground-based rescue robots were deployed in the 2001 attack, there is still no 'ultimate' rescue robot nearing application within the next few years. The main difficulty for these robots, including those used on 9/11, lies in the amount of debris found at most disaster sites. Rescue robot design is a trade-off between building a robot small enough to enter narrow holes and passages and big enough to cope with large amounts of debris. It is a design challenge that remains to be solved.

While most robots deployed in these situations have followed a caterpillar model researchers at EPFL have been working on a very different type of robotic system. The Laboratory of Intelligent Systems in partnership with the miniature mobile robots group (MOBOTS) have been exploring a 'swarmanoid' approach. "We wanted to show that we can use a bunch of simple robots to achieve things that people normally would think humanoid robots are required for." said Professor Floreano.



Left: active Foot-bot. Above: top view of current Foot-bot prototypes.

The researchers chose three essential humanoid functions: the ability to see, to grip and to walk. Using smaller, relatively simple robots, each specialised in one task and able to attach to and communicate with other robots, the researchers created a 'swarm' of robots, which in combination can fulfil complex tasks. "We developed the 'eye-bots', which can quickly be deployed into the building and can attach to the ceiling and scan the room for a victim. Then they can detach and fly to another area." explained James Roberts, a PhD student working on the project.

Amongst other features, the eye-bot is equipped with a 360° pan-tilt camera system, a 360° optical environment distance scanner and six brushless motors. A 3D positioning sensor allows it to locate and communicate with other robots, an important feature in a swarm. The current prototype attaches to the ceiling through magnetic forces, however in the future other attachment mechanisms will have to be explored for use in real-life scenarios. "The problem is, whenever you have a difficult situation, there is a lot of debris. With flying robots, if they can survive or even exploit collisions, I think we have quite promising candidates for the future in search and rescue." said Professor Floreano.

FOOT-BOTS DOCK WITH HAND-BOTS

In addition to the eye-bot built by the Laboratory of Intelligent Systems, the MOBOTs group led by Francesco Mondada has developed a hand- and a foot-bot to complete the 'swarm' and add two essential functions. The foot-bots are based on a modular all-terrain robot built earlier by the same group, called the MarXbot. The robot is equipped with two

LiPo batteries - allowing for four to eight hours of activity, a range and bearing positioning system, a camera and microphones as well as several infrared sensors to avoid collisions and detect other robots. Foot-bots can dock with other foot-bots as well as the hand-bot using a specially designed docking ring. They can thus form chains of collaborating robots, which could potentially move heavy loads such as debris or even disaster victims.

Three of these foot-bots are ideally needed to transport one hand-bot. The hand-bot was designed to grip and manipulate

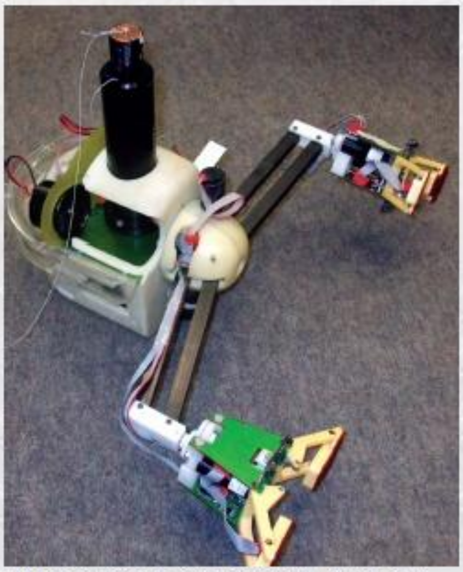
Far Left: Hand and Foot-bot with roboticist Micheal Bonani. Center: Hand-bot grips with 4kg pressure any object which activates the sensors. Above: close view of the Hand-bot gripper.

objects as well as climb vertical surfaces. For this purpose it is equipped with two powerful 'hands' or grippers and a rope, which is launched by the robot and attaches to the ceiling. The current prototype uses magnetic forces for attachment, like the eye-bot.

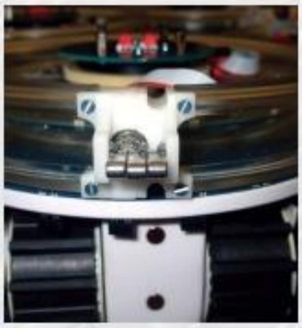
The hand-bot has twelve motors, two in each hand - one for grip and one for rotation – two motors to move each arm independently and one to rotate the arms, three for the rope and two for fans, which can be used to stabilize the robot when climbing or descending the rope. The grippers are equipped with seventeen sensors, including twelve infrared sensors, a camera and a position and torque sensor. The eye-, hand- and foot-bots are designed to work together and communicate with each other, so that optimal collaboration is achieved to fulfil a certain task, such as finding the victim of a disaster buried under a collapsed building.

Even though the idea behind these robots is promising, they are not yet ready for use in real-life situations; as Francesco Mondada noted: "I don't believe this is something for the short term, but in the long term, the idea of having distributed systems such as the swarm-bots, which can go into the danger zone and collect data, is good; however, I don't think it will be possible to actually move somebody."

Rescue robots like these, if finally ready for application will become an additional tool in the kit of rescuers. The decision to deploy a robot rather than a human or canine rescuer will depend on the individual situation and circumstances. However, ground-based rescue robots have great potential to help rescuers in tough situations and the search for a good all-round rescue robot will undoubtedly continue. ⊗



Above: current Hand-bot prototype. Above right: attachment ring and mechanism on Foot-bot. Right: close view of the attachment between Foot- (left) and Hand-bot (right).



Jana Witt visited the École Polytechnique Fédérale de Lausanne (EPFL) robotics labs through a project funded by the European Commission called RELATE (REsearch LAboratories for TEaching journalists). The project aims to bridge the gap between science and society and to enable young science communicators to experience research first hand. — the Editors

Links

Biorobotics Laboratory, http://biorob.epfl.ch

Laboratoire De Systemes Robotiques (LSRO), http://mobots.epfl.ch

Laboratory of Intelligent Systems, http://lis.epfl.ch

Relate (Research Labs for Teaching Journalists, www.relateproject.eu

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