By Commander R. (Bart) Everett (rtd)

Land Operations

Indoor fielding of US particle robotic security systems is already underway and outdoor testing will start soon.

Breaking down the Barriers

The benefits offered by a robotic security/surveillance capability are numerous. Humans are removed from direct exposure to potential danger, robots do not get bored or inattentive during long hours of surveillance and are never responsible for 'inside jobs'. Increases in theft, violence and even terrorism, with escalating costs of manpower and training, clearly indicate robotic systems as an evolving alternative approach to security.

Robotic site-security applications also have certain advantages for more ambitious battlefield scenarios. The operating environment can, to some degree, be tailored to support robotic installations. Experience-based costs of conventional security measures and documented inventory shrinkage provide a credible basis for cost/benefit trade-offs.

Nevertheless, almost 20 years have elapsed since industry and the US Department of Defense began taking an active interest in this promising field. Preliminary systems are only now achieving the required degree of practicality to warrant serious consideration. A number of pioneering efforts tested indoors, from the early 1980s, have significantly influenced existing follow-on systems (now ready for external environments).

ROBOTIC DEVELOPMENTS

ROBART I was the first of the fully autonomous security robots to be demonstrated. Detecting potential intruders with a variety of motion sensors, it moved through a semi-structured environment whilst avoiding obstacles. It could automatically locate and dock with a recharging station when its batteries began to run low. Sensors included a head-mounted passive infra-red

The Cybermotion Cyberguard SR3 is based upon the K3A platform and SPI-01 security sensor package.

The MDARS-Interior robot with the enhanced SPI-02 security sensor suite on patrol at Camp Elliott.

(PIR) motion detector and three optical motion sensors for additional detection capability.

Developed at the Naval Postgraduate School, Monterey, CA, in 1980-1982, ROBART I was intended as a crude feasibility demonstration for the concept of a fully autonomous indoor security robot. It could only detect the movement of suspected intruders, with no assessment capability to filter out nuisance alarms.

ROBART II, the second-generation follow-on, was developed in Springfield, VA, in 1982-1986 and made available to the Naval Ocean Systems Center (now SPAWAR Systems Center) in San Diego, CA. The robot's distributed architecture of 13 processors with a significantly augmented sensor suite (seven different types of motion detectors) made it ideal as a test-bed for enhanced navigation and intelligent security assessment.

The addition of an absolute world model allowed it to determine its location in world coordinates, create a map of detected obstacles and potential intruders, and perform multi-sensor fusion on the data from its security and environmental sensors. The latter allowed the implementation of a sophisticated threat-assessment algorithm that significantly increased the probability of detection whilst virtually eliminating nuisance alarms.

The first outdoor robotic sentry/surveillance system was the *PROWLER* (Programmable Robot Observer With Logical Enemy Response), developed during 1983-1985 by Robot Defense Systems (Thornton, CO). It was initially used as a tele-operated vehicle, based on Standard Manufacturing's diesel-powered six-wheeled hydrostatic-drive chassis. RDS performed incremental evolutionary upgrades to allow near-term deployment of limited-capability PROWLERs in very structured operating conditions.

In 1985, the PROWLER successfully demonstrated an ability to autonomously follow a non-linear 500 ft fence line in an outdoor test for the US Army at Fort Lewis, WA, using its side-looking laser rangefinder. Application-specific security sensors included a turret-mounted surveillance camera that could be vertically extended (up to 28 ft) using a special telescopic mast.

Development of the *Denning Sentry* as an indoor security robot (Denning Mobile Robots of Woburn, MA) began in August 1983. Polaroid ultrasonic rangefinders improved the navigational solution by allowing the robot to measure its offset as it approached a wall structure, whilst supporting a fairly robust obstacle detection capability. More importantly, the ranging sensors eased later development of a powerful wall-following algorithm that reduced dependence on the optical beacon system, increasing flexibility in the event of required path changes and reducing the need to modify the robot's environment.

CURRENT CONTENDERS

Actual fielding of particle robotic security systems has already begun for interior applications, and expansion into exterior environments is foreseeable in the near future. The principle contenders in this race are:

The *Mobile Detection Assessment and Response System (MDARS)* is a joint US Army-Navy development effort to provide an automated intrusion detection and inventory assessment capability for use in DoD warehouses and storage sites. The programme is managed by the Physical Security Equipment Management Office (PSEMO) at Ft Belvoir, VA, with overall technical direction provided by the Navy's SPAWAR Systems Center, San Diego, CA. The patrolling MDARS platforms detect anomalous conditions (such as flooding or fires), as well as intruders, and determine the status of inventoried items with specialised RF transponder tags. Separate development efforts target warehouse interiors and outdoor storage areas.

Initiated in 1988, the MDARS Interior program uses the K2A Navmaster mobility base developed by Cybermotion, Inc, equipped with additional collision avoidance, intruder assessment and product inventory subsystems. A Broad Agency Announcement (BAA) contract was awarded to Cybermotion in 1995 to develop a significantly improved intruder detection sensor package with an integrated camera pan-and-tilt mechanism.

Simultaneous control of two robots, patrolling nightly within an interior warehouse environment, has been demonstrated for almost a year in an Early User Appraisal installation at a Defense Logistics Agency warehouse at Anniston Army Depot in Alabama. The MDARS-Interior program is scheduled to transition to Engineering Development in early 1998 with a formal request for proposals (RFP) being issued shortly thereafter and operational fielding planned for the year 2000.

The MDARS-Exterior Programme, initiated in 1993, awarded a BAA contract for the development of the outdoor remote platform to Robotic Systems Technology (RST), Westminster, MD. The mobility base is a rugged, four-wheel, hydrostatic-drive, diesel-powered vehicle equipped with active laser, ultrasonic sonar, millimetre wave radar and stereo-vision sensors for collision avoidance. ▶

The MDARS-Exterior platform patrolling at the DoD Force Protection Equipment Demonstration in Quantico, VA.

The prototype automated response robot ROBART III under development at SPAWAR Systems Center.

A formal demonstration of autonomous navigation along straight-line path segments, under differential GPS control, was conducted at the contractor's facilities in October 1996. Automatic collision avoidance and limited intruder sensing (using image-stabilised video motion detection) was demonstrated in September 1997 at the DoD Force Protection Equipment Demonstration held at the Marine Corps Air Station in Quantico, VA. Additional efforts will focus on autonomous transit of non-linear path segments and fully integrated intrusion detection employing both video and Doppler radar.

CYBERGUARD

The first Cyberguard SR2 platform was introduced by Cybermotion in 1990, based on its three-wheel synchro-drive K2A Navmaster autonomous mobility base.

Early Cyberguard models were equipped with environmental sensors and a CCD camera, which relayed real-time video over an analogue RF link back to a central security console. A guard could then remotely control camera pan-and-tilt functions. Continuous time-lapse video recording took place on board the robotic vehicle for archive purposes but no automated motion sensors were initially employed.

In 1994, a rotating intrusion detection sensor suite (SPI) was added, developed under a cooperative research and development agreement (CRADA) with the US Naval Ocean Systems Center.

The introduction of the upgraded six-wheel-drive K3A Navmaster vehicle spawned the Cyberguard SR3 option in 1996. A much improved security sensor package was developed under the MDARS interior BAA contract and made commercially available as the SPI-02 in late 1997.

ROBART III

The ROBART series of research prototypes has served the US Navy in developing the component technologies needed to support the MDARS programme. As the third-generation prototype, ROBART III is specifically intended to demonstrate the feasibility of automated response, using (for purposes of illustration only) a pneumatically-powered six-barrel Gatling-style weapon that fires simulated tranquilliser darts or rubber bullets.

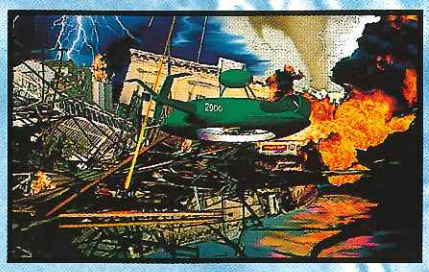
For increased versatility as a response vehicle, the navigation scheme has been specifically modified to support supervised autonomous operation in previously unexplored interior structures. A 'human-centred mapping' strategy is used to ensure valid first-time interpretation of navigational landmarks as the robot builds its world model. The accuracy of the robot's real-time position estimation (and ultimately the model representation) is significantly enhanced by an innovative algorithm which exploits the fact that the majority of man-made structures are characterised by parallel and orthogonal walls.

Widespread practical application of intelligent security robots is now an achievable reality for indoor environments, with exterior scenarios to follow. More recent attention has been afforded to automated inventory functions using off-the-shelf interactive RF transponder tags attached to sensitive or high value items. Robots have a valuable role to play. UV

Editor's note

Cdr Everett is the Associate Division Head for Robotics, Advanced Systems Division at NCCOSC RDTE. He has been active in the field of mobile robotics research since 1965, with over 70 technical publications and 16 related patents issued or pending.

SEARCH AND RESCUE ROBOT PRIZE



AUVSI's next Aerial Robotics competition, in the year 2000, is centred on the development of autonomous robots for human search and rescue. Up to US $30,000 will be awarded to the winner(s).

The scenario is the aftermath of a major catastrophe in which an urban area has been decimated by earthquake, tsunami and wind. The ultimate cause has been described as either 'volcanism, the impact of an erratic near-earth orbiting asteroid or multiple nuclear ground explosions triggered by terrorists'. Rob Michelson, the competition's creator, described the mission for research teams.

'Information is unavailable to you – all you and your design team know is that your research facility has somehow survived the night along with its complement of autonomous robots. Chemical fires are raging, toxic clouds of smoke choke the skies and obscure the view.

'Your sensors indicate that low level radiation is present. There are other survivors out there who are injured and must be found before they die. Your autonomous robots have to be reprogrammed to search for living humans on the ground and either find and report their location to the human rescue team or, if possible, attempt to extricate the survivors.'

The robots must be robust enough to operate in a realistic environment with wreckage, fire, smoke, aerosols, acoustic shock waves, motion on the ground and in the air, as well as unbriefed obstacles.

Alternative targets of interest (such as drums of hazardous material) will pose potential threats to rescue teams in the area.

Various qualifiers, over 1998 and 1999, must be passed to become a finalist in the Millennial Event.

The first qualifier will involve demonstration of fully autonomous flight over a large area (five acres or more) containing briefed obstacles. Aerial robots must be able to locate at least one of several items encountered.

The official rules and application can be accessed on the world wide web at http://avdil.gtri.gatech.edu/AUVS/IARCLaunchPoint.html

A selection of current research, technology and development efforts around the world.

IN A NUTSHELL...

A research team at the Naval Postgraduate School (Monterey, USA) is looking into the use of micro unmanned aerial vehicles. Designed to be operated by an individual soldier, they can provide potential aerial support to special forces or inspect hazardous areas.

The aim is to fit sensors (such as video, radiation, chemical and possibly GPS) into a small, graphite cannister weighing no more than a piece of paper. They may also be used as communication relays. Alternative power sources are under investigation.

'If you use a battery, it's too heavy,' commented Professor David Jenn. 'We are using an offboard source of energy. An antenna would track the vehicle and provide a microwave beam to provide energy to the vehicle.

The vehicle receives it, rectifies it, then uses that energy to power the motor. The antenna we are working on is multi-directional, so it can continue to send energy no matter where the micro UAV is. We've also been able to use the body of the aircraft as an antenna.'

Micro UAV programmes, based upon the principles of insect motion, are also under investigation at institutes such as Georgia Tech (USA).

The Australian Defence Force is looking at micro UAVs to improve its surveillance capability. An Aus $300,000 project to build a robotic flying 'insect', jointly funded by Australia and the US, will run until mid-1999.

The team comprises Dr Sanjay Mazumdar and Dr Colin Coleman from DSTO's Weapons Systems Division, Professor Srinivasan, Dr Javaan Chahl, Dr Jochen Zeil (Australian National University) and Ric Wehling (Elgin Air Force Base, USA).

NAVAL UCAV RESEARCH CONTRACT

US Naval Air Systems Command has awarded Lockheed Martin a contract to define a family of uninhabited naval strike aircraft concepts to prove launch capability from a variety of naval surface ships, as well as ballistic-missile submarines.

The company will define three notional uninhabited naval strike aircraft: a short take-off and vertical landing (STOVL) concept, a vertical attitude take-off and landing (VATOL) concept and a submarine-launched VATOL concept. The VATOL configuration would be able to launch and recover vertically using jet-powered or rocket-assisted lift. The study will include aircraft launch and recovery directly from decks, pads or elevators or VATOL operations from alongside the ship or off the stern. The VATOL and STOVL configuration will be capable of operation from various types of air-capable surface ships (including destroyers, cruisers, small-deck amphibious ships and carriers).

The third, and most revolutionary configuration, is a VATOL concept which would launch from the ballistic missile tubes of a submarine and be recovered on land or surface ships.

'One of the reasons Lockheed Martin was chosen for these studies is the vast amount of research and development work we have done in the area of uninhabited combat air vehicles, as well as our heritage of developing advanced aircraft as part of the Fighter Enterprise,' explained Armand Chaput, integrated product team leader for UCAVs.

Uninhabited naval strike aircraft concepts will be based on missions for attacking high-value fixed targets or for suppressing enemy air defences (SEAD) within a range of 600 miles. The initial contract is expected to be completed by May 1998.

ITS A MUST

The US Army is extending its 'Bird Dog' research project to demonstrate the capability of manned and unmanned systems working together on the battlefield. The Bird Dog project (covered in the May 1996 issue of *Unmanned Vehicles*) focused on the development of a small autonomous UAV.

Under the new Airborne Manned/Unmanned System Technology (AMUST) programme, the issue of integrating UAV platforms with attack and scout helicopter operations is under examination.

An advanced technology demonstration (ACTD) is planned for 2000-2004 and, in the meantime, the US Army will examine issues such as command and control for the helicopter and the UAV.

Editor's note

If you would like to inform readers of your R&D or technology development efforts, or solicit help for co-operative projects, please send details and photographs to Sara Waddington at Unmanned Vehicles *(fax: +44 (1628) 664334 or e-mail: heli-uv@shephard.co.uk).*