Selected 2010 The Royal Society's 350th anniversary Summer Science Exhibition

Robot detectives: Sherlock Holmes meets Spiderman

Selected for the Royal Society's 350th Anniversary celebrations in the Royal Festival Hall, June 2010

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royalsociety.org

1 October 2009
Our ref: RF09/SSE

Dear Dr Sattar,

Summer Science Exhibition 2010

I have great pleasure in informing you that your proposal to exhibit **Ultrasound inspection of critical infrastructure with wall-climbing robots** at the Royal Society's 350th Anniversary Summer Science Exhibition at the Southbank Centre in London has been successful. We very much look forward to working with you on this event.

I would be grateful if you could formally accept the invitation to exhibit at the Royal Society Summer Science Exhibition in 2010 by signing the enclosed form. Please return to Rachel Francis by Friday 16 October 2009.

As a successful exhibitor you are required to attend, or send a member of your team to attend, the Exhibition Planning Day at the Royal Society on Wednesday 28 October 2009, with arrival and coffee from 10.15am, and the presentations beginning at 10.30am. The programme will end at 5.30pm, with an optional trip to the Southbank Centre at this time available for those who would like it. Planning Day is an excellent opportunity to find out more about all aspects of your involvement in the Exhibition. It is also an opportunity for the Science Communication Section to discuss your exhibit with you in more detail and give feedback from the selection committee. The day will include:

- an introductory session explaining what the Exhibition is about and what to expect from the week;
- a talk from some of the 2009 exhibitors, outlining what worked well and badly for them;
- a short session on good communication practice;
- an opportunity to speak to staff about your exhibit and ask any questions you may have and time for more informal interaction between exhibitors and staff.

The success of the Exhibition depends very much on the preparation undertaken beforehand and previous exhibitors have found this planning day invaluable. Please could you confirm who from your team will be attending by completing and returning the enclosed form by Friday 16 October 2009.

If you have any queries about any element of the Exhibition, between now and Planning Day, please do not hesitate to contact Rachel Francis on Exhibition@royalsociety.org, or 020 7451 2244.

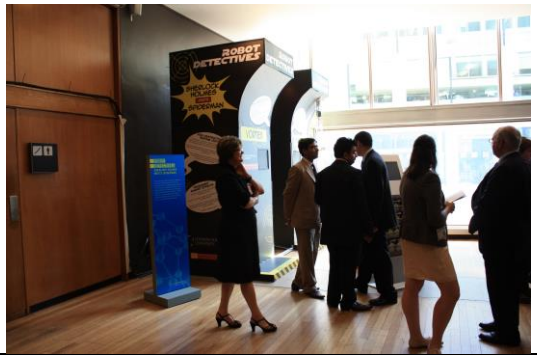
Congratulations on your successful proposal and we look forward to hearing from you soon.

Yours sincerely,

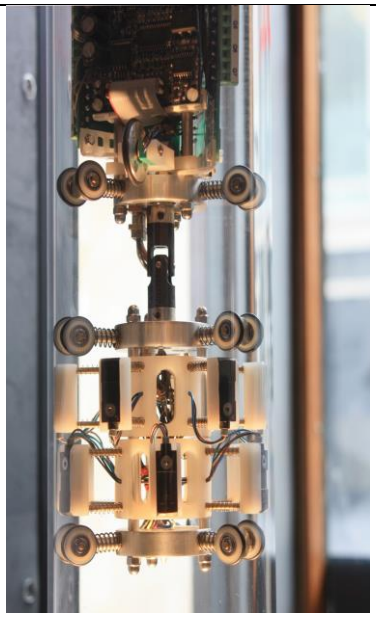
Katherine Jarrett

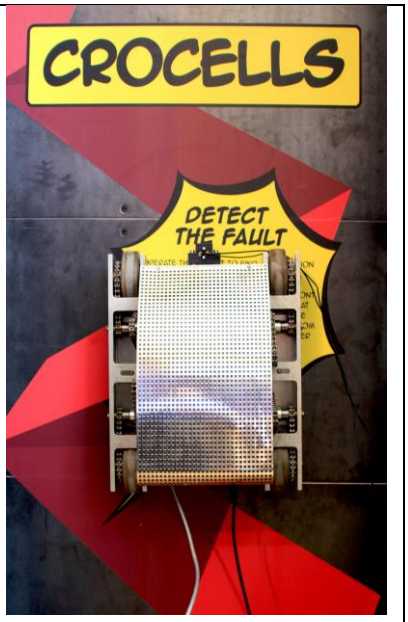
Katherine Jarrett
Head of Science Communication

The Robot Detectives display and visitors at the convocation of the Fellows of the Royal Society

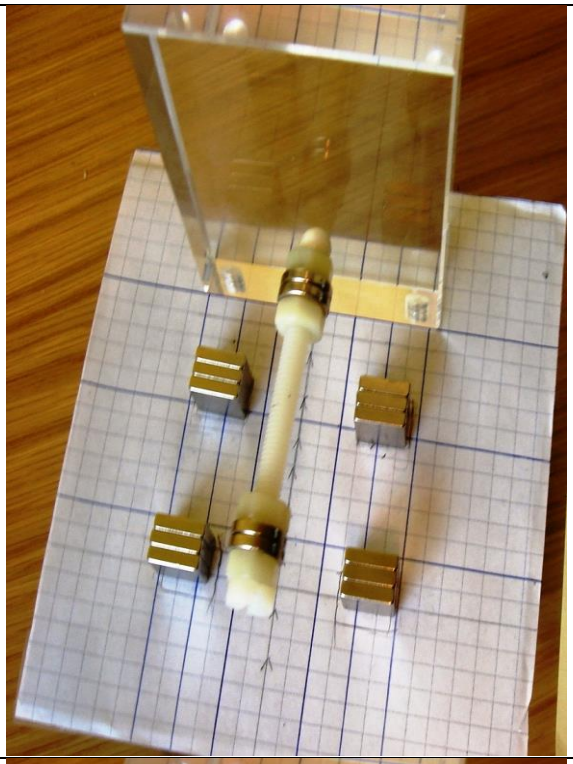


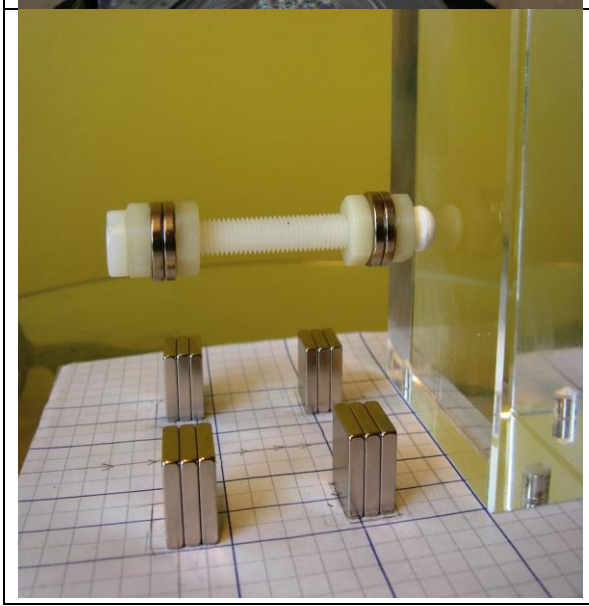
Wall and pipeline climbing robots exhibited at the Summer Science Exhibition

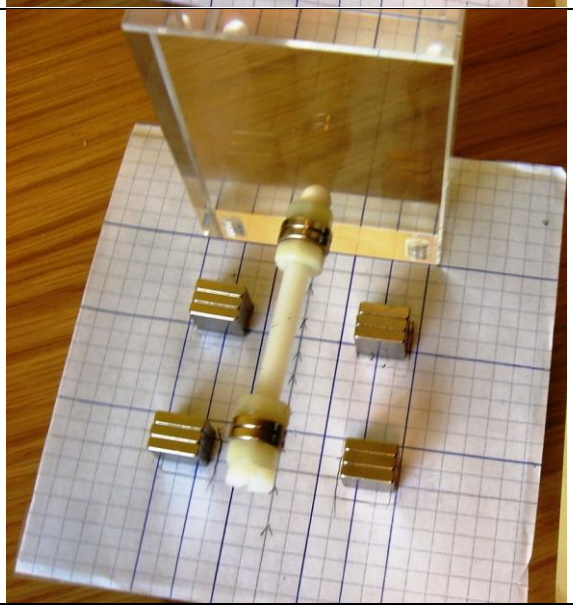




Magnetic flux focussing and levitation exhibits







Robot Detectives: Sherlock Holmes meets Spiderman

Researchers from London South Bank University are collaborating with other institutions to create inspection robots able to climb walls and swim.

Mobile robots can have many uses, from security to domestic applications. Researchers are developing mobile robots able to climb walls and swim to perform non-destructive testing of critical infrastructure using imaging techniques. They can work in remote and hazardous environments that human testers can not access, such as nuclear pressure vessels and the fuselage of aircraft. By utilising state of the art technology they are able to adhere to different surfaces using magnetic and vortex vacuum adhesion. Swimming and amphibious robots are able to perform in-service inspection of the floors and walls of petrochemical storage tanks whilst immersed in the liquid product.

"The robots we are developing are able to perform non-destructive inspection techniques for a wide range of applications from industrial inspection, surveillance, and security," says Dr Tariq Sattar, London South Bank University.

Visitors to the exhibit were able to see the technology behind these new robots and how the robots use ultrasonic and electromagnetic techniques to perform their tasks.

Three points put across to visitors to the exhibition

1. PURPOSE: Our research is developing mobile wall climbing and swimming robots to inspect large remote structures that are difficult and expensive to get to and may be located in hazardous environments which prevent human inspectors from reaching them. The robots will make huge savings in inspection costs by not having to erect scaffolding or making lengthy preparations to gain access to test sites. Where possible, the robots are designed to enable in-service inspection thereby preventing plant outages and hence loss of production.

Erection of scaffolding in the Odense Shipyard (Denmark) to inspect many kilometers of weld lines

2. WALL CLIMBING: How do the robots climb on vertical surfaces? The exhibit demonstrated two methods – magnetic adhesion and negative pressure. Hands-on experiments explained permanent magnetic adhesion with small magnets and show other interesting things you can do with permanent magnets such as levitation.

3. DETECTION: How are hidden defects such as corrosion, cracks, inclusions, etc. found? The exhibit demonstrated ultrasound techniques and eddy current techniques with hands-on demonstration.

The exhibit demonstrated the following five wall-climbing robots.

1. Two robots use permanent magnet adhesion. They climbed on a steel wall. Figure 1 shows the CROCELLS robot. The robot is controlled wirelessly. It deploys phased-array ultrasound to look for weld defects in tall steel structures such as the hull of a cargo container ship. The defect data is sent for analysis to the laptop of an operator sitting comfortably away from the test site.

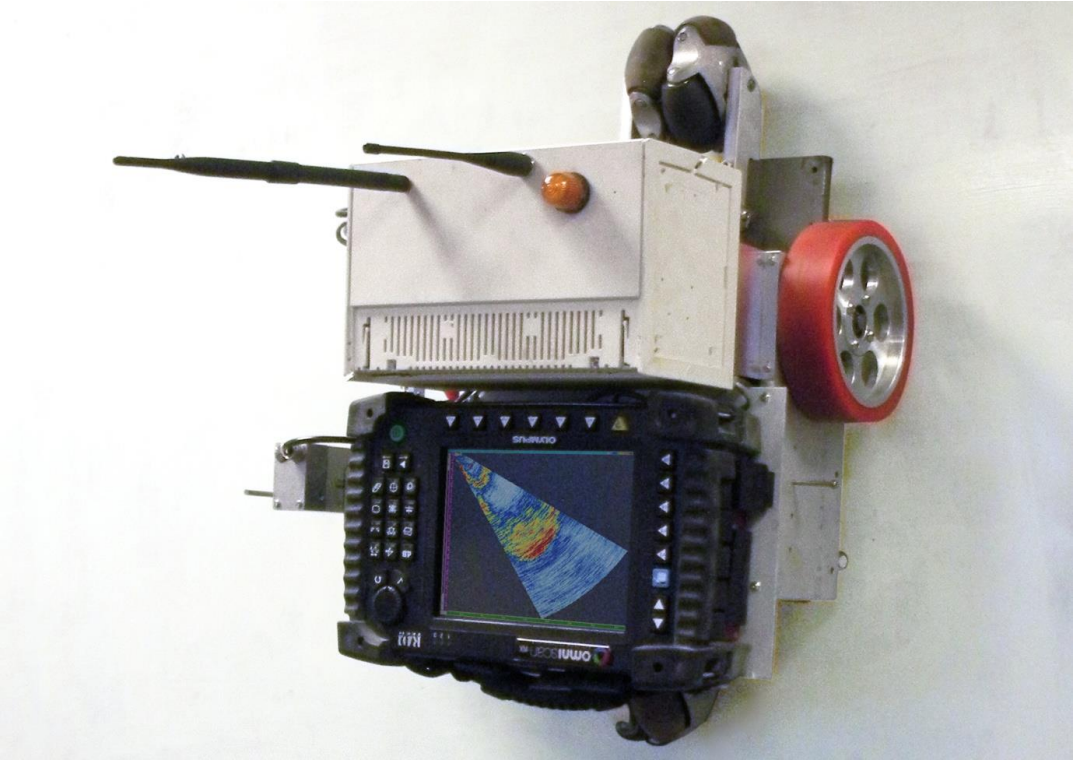


Figure 1: The CROCELLS robot – uses magnetic adhesion to climb on steel structures

The second climbing robot, called STRONGMAN, also climbs on steel plates using magnetic adhesion. It is equipped with an ultrasonic probe to detect thinning of the 6mm thick steel wall which simulates corrosion thinning. It is controlled with a simple pendant to allow the public to teleoperate it on a steel wall and challenged to find the hidden defect.

Figure 2: STRONGMAN climbing on a steel wall

2. One robot that climbs on non-ferrous surfaces such as glass, brick, concrete, wood, etc. This is called the VORTEX robot. It uses negative pressure to adhere to a surface. It is designed to inspect structures such as high rise buildings, dams, glass fronted buildings, etc.

Figure 3: Vortex robot climbing on glass with vision system sending images to hand-held controller

Figure 4: The Vortex robot climbing on a brick wall

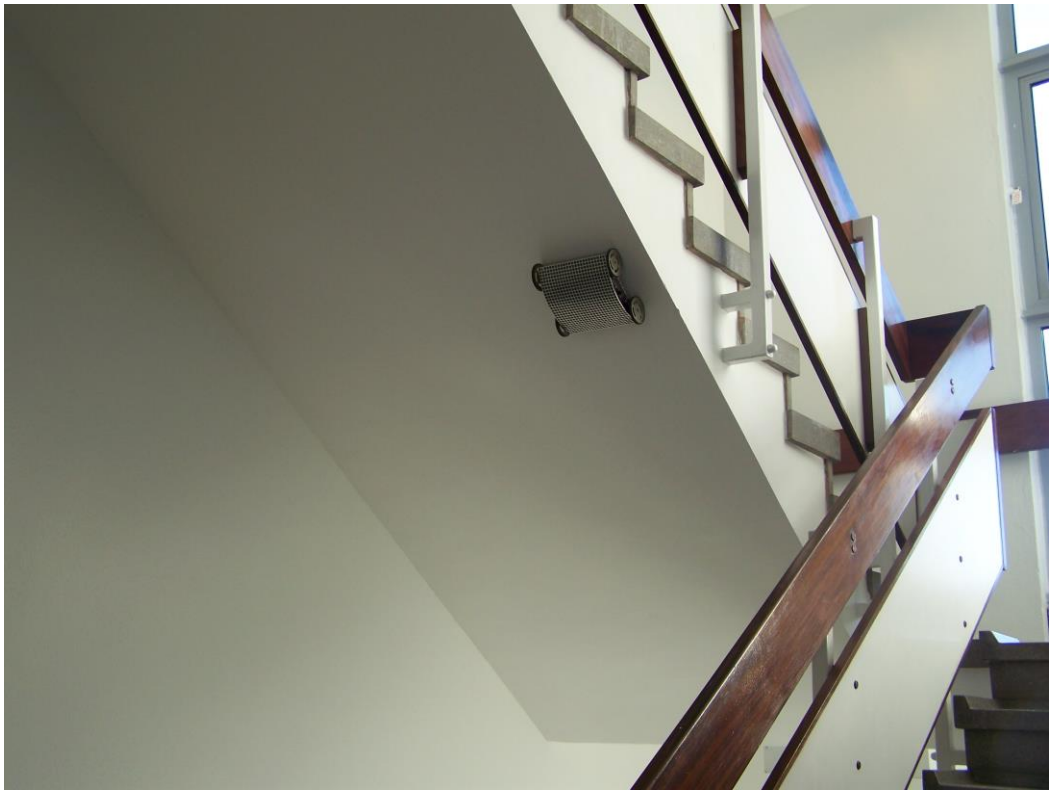


Figure 5: The Vortex robot on a stair well.

Figure 6: The Vortex robot with a vision system climbing on the glass front of the Keyworth building

3. Two Pipe climbing robots. One robot is designed for the internal inspection of pipes to detect cracks, corrosion, and fouling in long pipelines such as food processing plants, buried oil and gas pipelines. The other robot, called the RING robot, climbs on the outside diameter of pipes to inspect the pipe for internal corrosion, cracks and fouling. This robot is also being developed to climb on lighting poles and the towers of wind turbines to inspect wind blades.

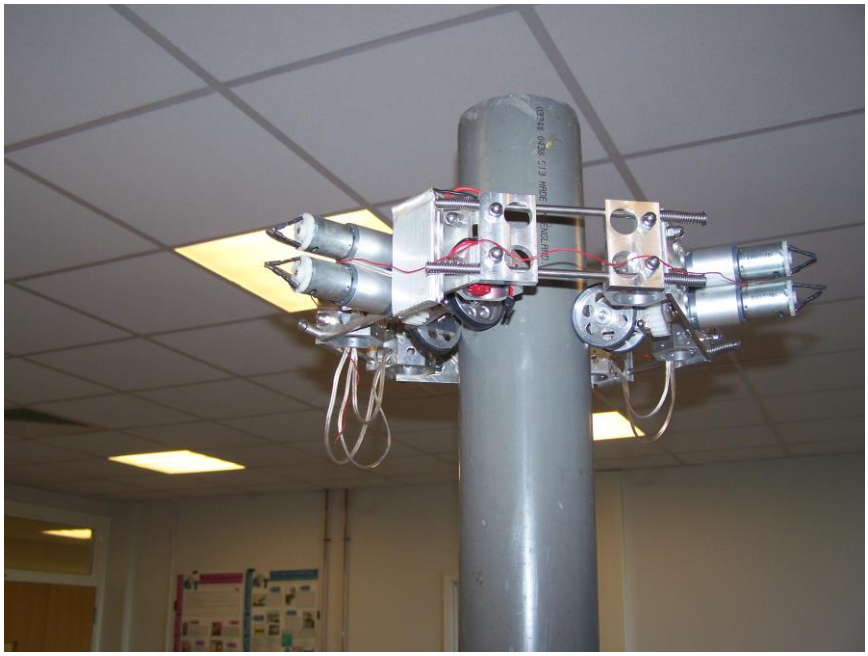


Figure 7: The RING pipe climber can climb straight up-down or spiral up-down a pipe

Permanent Magnet Effects

1. The way to focus magnetic flux was demonstrated by asking a visitor to pick up a heavy looking steel block with a tiny magnet. This will not be able to do so. Then a simple way to focus the flux was shown. The small magnet will be able to pickup the block. This will show how we have used permanent magnets to build large payload carrying capability in our climbing robots.

2. With suitable arrangement of permanent magnets, we showed how another magnet or sets of magnets can be made to levitate in air at a stable equilibrium. Figure 11 shows a levitating set of magnets.

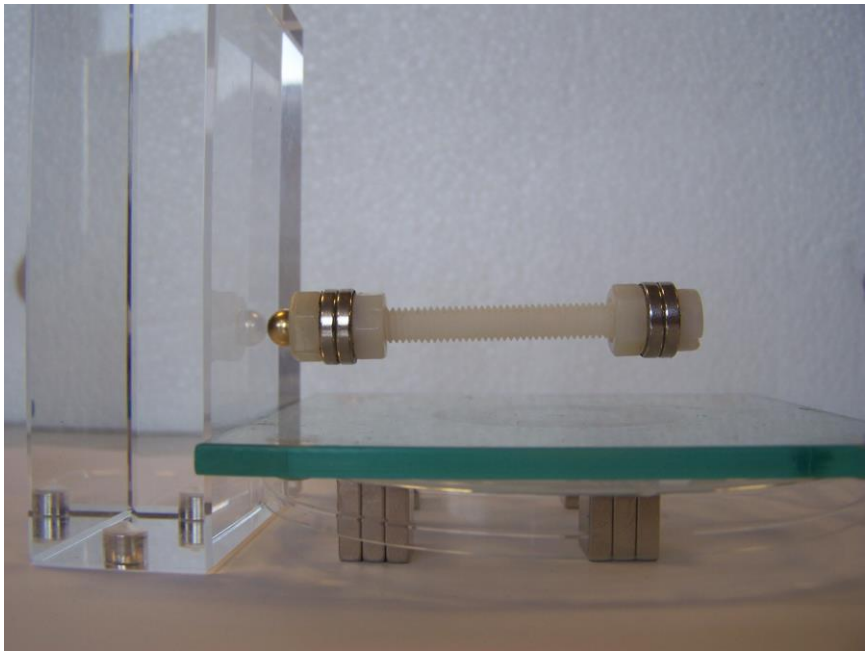


Figure 11: Levitation with permanent magnets only.

3. **By spinning a permanent magnet, we showed it levitating in air on top of a ring magnet, see Figure 12**

Figure 12: Spinning disc magnet levitating above another ring magnet

4. The motion of a permanent magnet induces eddy currents in electrically conducting materials. These oppose the motion of the magnet causing them. We will use these effects to descend a falling magnet slowly onto a copper block and through a copper tube. The motion of a permanent magnet will be used to identify different types of hidden materials.

Hands-on Ultrasonic NDT

One work station was devoted to enabling visitors to find a hidden defect in an aluminium block using an ultrasound probe.

Figure 13: Ultrasonic testing hands-on display to find a hidden hole defect in a test block.

Two video loops with a voice over showed film of the robots on 15 inch monitors in two separate locations.

Swimming and amphibious Wall Climbing Robots for the inspection of storage tanks, pressure vessels

These films also show three submerged robots that we are developing to inspect the floors and walls of petrochemical storage tanks and welds in nuclear pressure vessels.

1. The ROBTANK robot is being developed to operate in a petrochemical storage tank when it is full of product. It enters through manholes on the roof of a tank, descends to the floor and inspects the floor for corrosion and pitting using ultrasonics. Figure 8 shows the robot on top of a water storage tank in the Petrogal Sines refinery in Portugal.

Figure 8: The ROBTANK storage tank floor inspection robot

Figure 9: ROBTANK immersed in water in a fire figting tank in the Sines refinery.

2. The FPSO amphibious robot can both swim to a given test site on the wall or floor of a storage tank and move around the floor to inspect it. It is being developed to inspect tanks for floating production and storage of oil. Figure 10 shows the FPSO swimming in water in a diving tank.

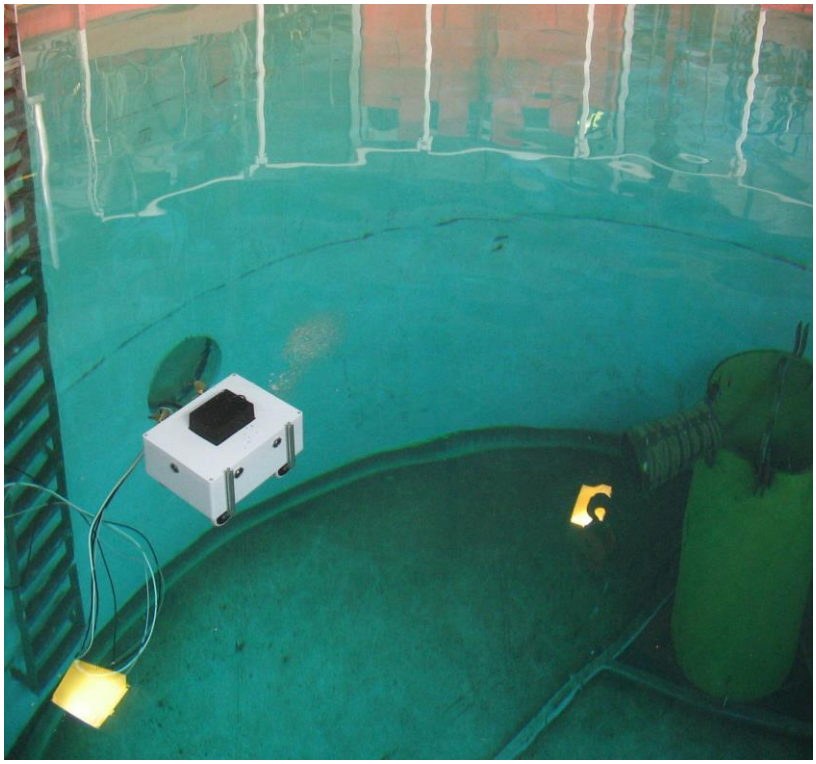


Figure 10: FPSO robot is able to swim to a given depth or location and move around on the floor with wheeled motion.

3. The RIMINI robot climbs on the walls of storage tanks and pressure vessels to look for defects.

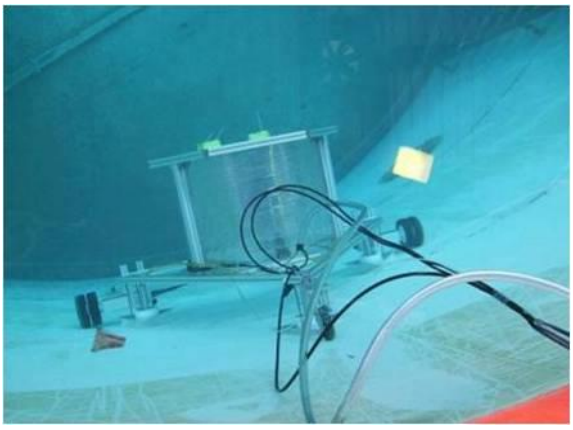


Figure 11: The RIMINI robot climbing the walls of a storage tank using suction cup adhesion.

The following media reported our exhibit titled "Robot Detectives: Sherlock Holmes meets Spiderman" at the Royal Society's Summer Science Exhibition.

1. Robot detectives: Sherlock Holmes meets Spiderman
New Scientist
10:51 25 June 2010 by Catherine de Lange

http://www.newscientist.com/article/dn19086-robot-detectives-sherlock-holmes-meets-spiderman.html
This gravity-defying robot can climb walls and even cling to the ceiling, using a vortex vacuum to hug to the surface. Other robots designed by the team from London South Bank University can swim under water, or use a clever circular design to move around the outside of pipes and tubes.

These access-all-areas robots are remotely controlled and carry equipment such as ultrasound scanners that they can use to test the integrity of the surfaces of buildings and other structures without causing any further damage themselves.

It also means they can get into areas that would be hard for people to reach. Swimming robots, for example, could be used to test the floors and walls of tanks storing hazardous liquids.

Attach a camera to the robot, and it can also be used in dangerous or sensitive situations to scope out a scene – for disaster relief or to spy on hostage-takers, for example. ------

2. BBC New, Science and Environment, Friday June 2010 Film.
The best of the UK's cutting-edge science, engineering and technology are on display at London's Southbank Centre as the Royal Society opens its summer science festival.

The interactive exhibition answers questions including how body shape affects health, how researchers work out what is going on inside volcanoes and whether there is a new ocean opening up in Africa.

The festival, which runs until Sunday 4 July, is part of the society's 350th anniversary celebrations.

BBC News took a look around some of the attractions on display.
http://news.bbc.co.uk/1/hi/science_and_environment/10409706.stm

3. Robots usher in Royal Society's 350th anniversary http://www.ft.com/cms/s/0/1b5dc100-7ff1-11df-91b4-00144feabdc0.html
Financial Times
One of the most striking exhibits comes from the London South Bank University, whose scientists are demonstrating their latest wall-climbing robots. ...

4. The Times Newspaper - Article

The TIMES Science Section

Robots usher in Royal Society's 350th anniversary

By Clive Cookson, Science Editor
Published: June 25 2010 03:00

Wall-climbing robots and flying robotic penguins are to inhabit London's South Bank as part of the capital's biggest science fair since the 1951 Festival of Britain.

One of the most striking exhibits comes from the London South Bank University, whose scientists are demonstrating their latest wall-climbing robots. These machines scale vertical surfaces