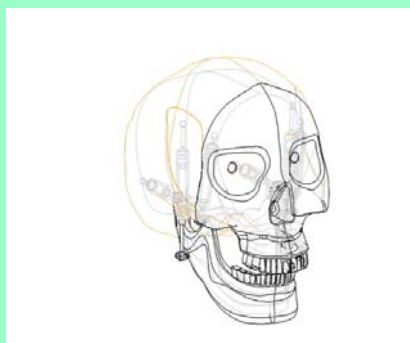
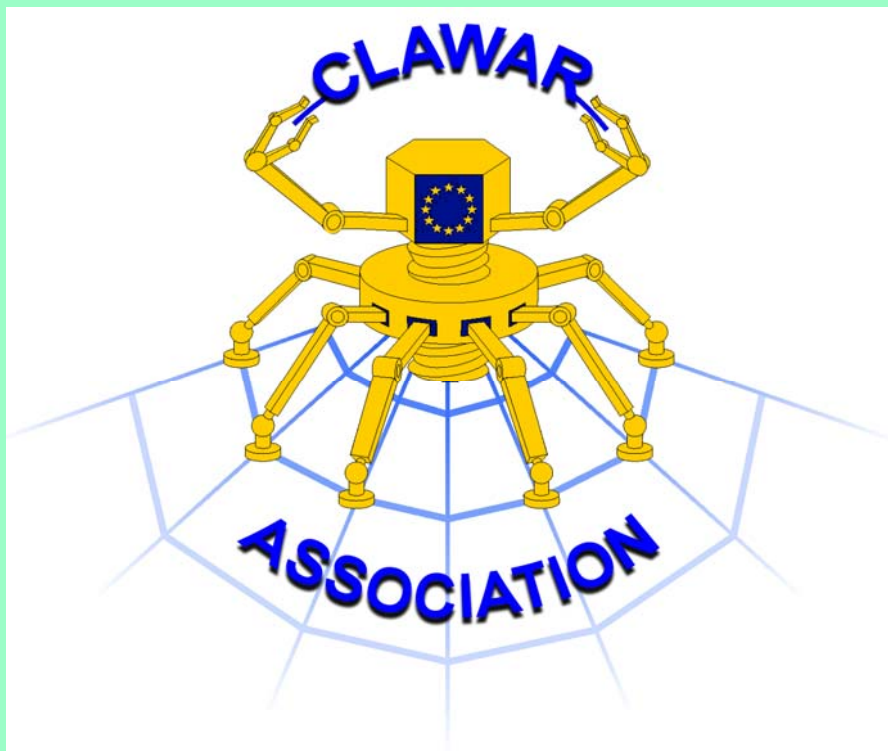


# CLAWAR News

Issue No. 18

May 2008



## In this issue:

- Chewing Robot
- News on ISO standards for service robots
- Humanitarian demining systems

And more...

*Editor: Loulin Huang*

*ISSN 1446-8491*

# CLAWAR NEWS

## The Newsletter of CLAWAR Association

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### Submission of Contributions

CLAWAR News is designed to provide information to members of, and interested parties to, the CLAWAR Association. Accordingly, the scope of the Newsletter covers a wide range of areas and topics that are in line with the mission and purpose of CLAWAR Association. Following is a set of sample areas, with possible length, that fall into the scope of the Newsletter that potential contributors may consider for submission:

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*Member profile:* Sketch profile of research group or research organisation involved in CLAWAR Association activities. Typically 500 – 1000 words long.

*Diary of events:* Information on forthcoming conferences, workshops, seminars, lectures and exhibitions that are relevant to the activities of CLAWAR Association and may interest members. Details of such forthcoming events to include full title of the event, venue, dates and times, contact details for correspondence including telephone and/or fax, email and web-site.

*Literature:* Information and/or review of new or recent books, new or established journals, new articles. In addition to authorship and publication details, a brief (100 - 150 words) description/outline of the nature and contents will be desirable.

*News about people:* New developments, launch of new research projects/programmes, research organisations/groups. Typically 500 - 750 words long.

*New trends:* Trends in research or development in context of thoughts or perception and desire within universities and industry at local or global level. Typically 500 - 1000 words long.

Please send your contributions by email in text or MSWord format with images (inserted in Word document or separate jpg format of at least 300dpi resolution) to the Editor for publication in a forthcoming issue.

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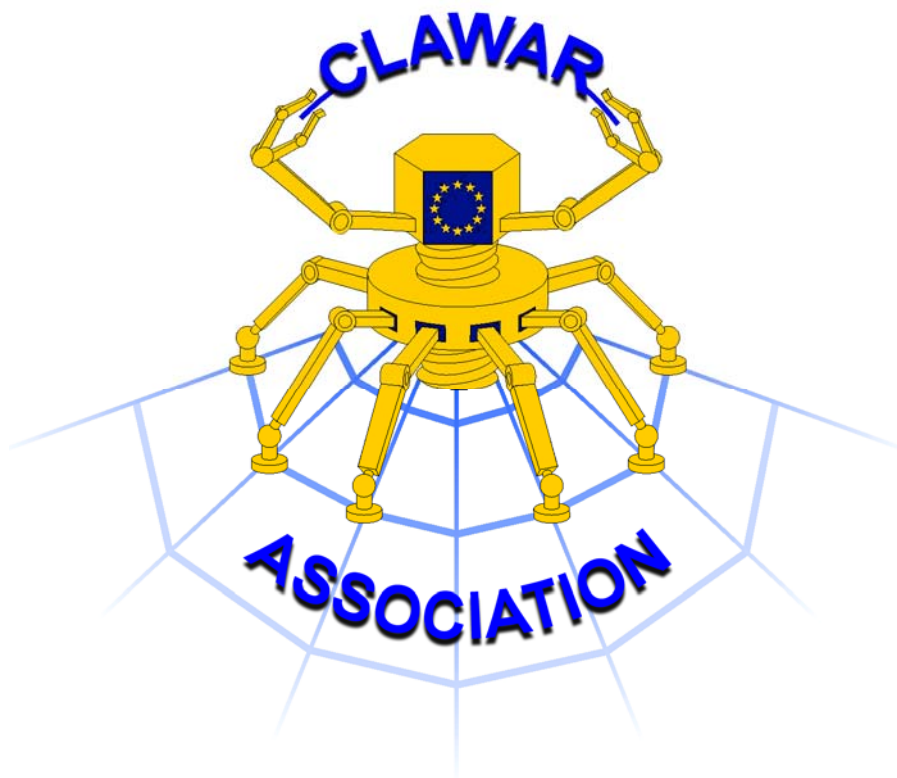
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***Editorial***  
***Loulin Huang***

The theme of this issue continues in the same vein as that of Issue 17, which is of course our favourite hot topic - the service robot. We also begin to bring you related news from New Zealand as well as Europe and other countries.

Compared to the many robot power houses such as Japan, USA and Europe, then New Zealand, an island situated remotely from the main continents, seems to be a quiet spot on the map of robotics research in the world. In reality, there are a lot of active research activities being carried out, and amazing results achieved by the local researchers who are well known among the population for their DIY (Do It Yourself) spirit. The special features of the New Zealand economy (agriculture, animal husbandry and forestry, to name a few) opens up an exciting domain, and provides a new flavour for the research in service robots.

One of the reports in this issue brings you a new robot which mimics the human food chewing process, which has been developed by a research team led by Professors Peter Xu and John Bronlund at Massey University. This is just one example of many service robots being developed in New Zealand.

Another sign of the booming robotics research in New Zealand, and neighbouring Australia, is that more and more robotics conferences are being held throughout Australasia. The Australian Conferences on Robotics and Automation (ACRA), organised by robotics professionals from Australia and New Zealand, has entered its 9th year. B. MacDonald has reported for us on the 9th ACRA, held in Australia in December 2007.

Two further conferences related to robotics, '15th International Conference on Mechatronics and Machine Vision in Practice' (M2VIP), and '4th International Conference on Autonomous Robots and Agents' will be held in New Zealand during 2008 and 2009 respectively. Their details can be

found in our "Calendar of Events".

In this issue, we also report on the annual robotic car competition held by the first year B.Eng students of Massey University, New Zealand. You will be amazed by the capabilities and eagerness of new engineering students to deliver good results in their projects.

In Feb 2008, the ISO meeting on service standards was also held in Wellington New Zealand. As the chairman of the ISO TC184/SC2 project team, Prof G.S. Virk has reported the activities and the outcomes of the meeting.

Having a good perception of the capability of a robot is essential for its acceptance and application in service areas. A new trend is to make it closer to the principles of living systems, which have dominated the service sectors. This is also the main motivation behind the European Commission's SPARK project. In this issue, P. Arena, and his team members, shares with us their works and achievements so far in the project.

C. Salinas and his colleagues have provided us with their research using an omni-directional vision system which they developed for humanitarian demining.

As this area of research is very much in the forefront of research and is becoming more and more interesting to the general public, then it can be foreseen that service robots will continue to dominate the theme of the Newsletter for a long time. I am hoping you would be willing to share your or your colleagues' research works and achievements with other members of our community through our Newsletter and we look forward to receiving your submissions.

Happy reading,

L. Huang

# Chewing it over - a robotic jaw takes shape

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(re-produced from Massey Research, Issue 3, 2006, pp. 41-43 )

Think for a moment about the mechanics of eating: of biting, chewing and swallowing. Evolution has bestowed on us the versatile jaws and teeth of omnivores. We can bite an apple using our incisors. We can crush nuts and grains using our molars. We can move our jaws laterally to tear at the fibres of a steak.

We adjust how we chew to match the type of food we are eating and how well-chewed it is already. And all the while our tongues are sorting the food particles – holding back the smaller ones and pushing the larger particles back between the teeth for further processing – shaping the ball, or bolus, of well-chewed, saliva-moistened food we will swallow.

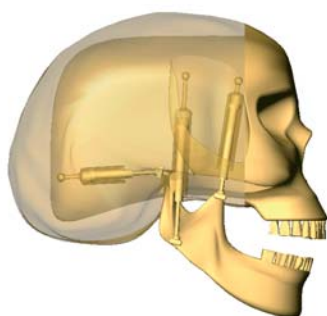
We experience the food: savouring its aroma, taste, temperature and – two properties that change dramatically as the food is chewed – its texture and mouthfeel.

For many foods, texture and mouthfeel are a large part of the sensory point. Take, for example, the crustiness and spring of newly baked bread, the crispness of an apple plucked from the tree, or the just-so give of spaghetti cooked al denté.

But how do you measure these qualities objectively and precisely?

The beginnings of an answer are taking shape on a laboratory bench in the form of a prototype robotic jaw.

The team developing the jaw is led by Professor Peter Xu, a specialist in mechatronics and Dr John Bronlund, from the School of Engineering and Advanced Technology of Massey University.



Over the past five years, they and their group have been coming to grips with the complicated architecture of the human jaw. The human jaw involves two rigid bodies, the upper jaw or maxilla, and the lower jaw, or mandible. The maxilla is fixed. The mandible is suspended from the skull through the hinges known as temporomandibular joints. A temporomandibular joint does not simply rotate around a fixed point, as does a joint such as an elbow or knee. Instead, within a fixed range, it is able to move backwards, forwards and sideways beneath the skull while rotating, making the range of paths potentially unlimited.



The movement of the mandible is driven and coordinated by muscle groups that broadly divide into those that open the mouth and those that close it. The mouth-opening muscle groups move the mandible away from the maxilla at high velocity, while the mouth-closing groups allow for the movement of the mandible against the maxilla with high forces. There's also a third muscle group, which isn't exclusively mouth-opening or mouth-closing.

Dr Xu's team has devised a six Degrees of Freedom model driven by six actuators, or motors. These six actuators, being bi-directional, are able to replace both the jaw-opening and jaw-closing muscle groups, allowing the jaw to follow all of the key trajectories they have identified.

It wasn't easy. In the confined space of the average human jaw – they wanted the jaw to be human-size – the six actuators kept getting in the way of each other. Creating a model that satisfied the demands of both speed and space meant adapting the original design. They expect to adapt it again.

The prototype of the robotic jaw was completed late in 2005. It looks like a small industrial robot built around a set of dentures, but then beauty is in the eye of the beholder. "It's a work in progress," agrees Dr Xu.





The impetus for the development of the jaw came eight years ago from Dr Xu's colleague and project co-leader Dr Bronlund, an Associate Professor in bioprocess engineering, who had just returned from a sabbatical based at l'Institut National de la Recherche Agronomique (INRA) in France.

While there, Dr Bronlund had worked with a group at the University D'Auvergne Clermont who were using an instrument called an articulograph to determine how people's chewing patterns changed according the properties of the food they were eating.

Volunteers wearing small transmitter coils on their teeth were seated in a magnetic field and a set of receivers monitored the movement of the coils.

The work took place under the auspices of the University School of Dentistry in the Auvergne. But while the focus was dental, Dr Bronlund was alert to other possibilities.

"I thought, you could take those monitored, measured jaw trajectories from a real person and make a robot to reproduce them. You could incorporate sensors, measure forces in real time, and arrive at quantitative measures of food texture dynamically, as the food is being chewed."

What are the attributes of food texture? Food technologists employ a lexicon of qualities, among them hardness, cohesiveness, viscosity, springiness, adhesiveness, fracturability, chewiness and gumminess.

Although we may not use this vocabulary, we are all exquisitely sensitive to these qualities in the food we eat, and indeed one way of assessing the textural qualities of a food is to convene a panel and have the participants rate food according to a sensory scale.

But humans are expensive to hire, and no two are the same. Their dentition and the structure of their jaws vary; their chewing patterns are idiosyncratic; their judgments are inexact. So it is not surprising that from the 1960s on, the food industry has increasingly turned to instrument-based methods to measure food rheology – the physics of

deformation and flow. These days food technologists can measure physical qualities such as adhesion, breaking point, creep, tackiness and spread with great precision.

But however well-engineered the instruments and however precise the measurements, 'meaningful' data – that is data that correlates well with the way we experience food – is hard to come by. A food product pressed between two flat plates, for example, is not a good analogue for action of your molars.

Nor are texture analysers, which typically take their measurements from a couple of consecutive 'bites', much good at chewing food.

And if you are trying to cook a more tender greenlipped mussel, then employing a texture analyser such as you might find in a food technologist's laboratory may not be that helpful, says Dr Bronlund.

"You can get any answer you want depending on whether you cut across the stringy lip or into fleshy body; different parts of the mussel have different mechanical properties."

A robotic jaw, on the other hand, programmed to reproduce the behaviour of a human jaw, would serve nicely.

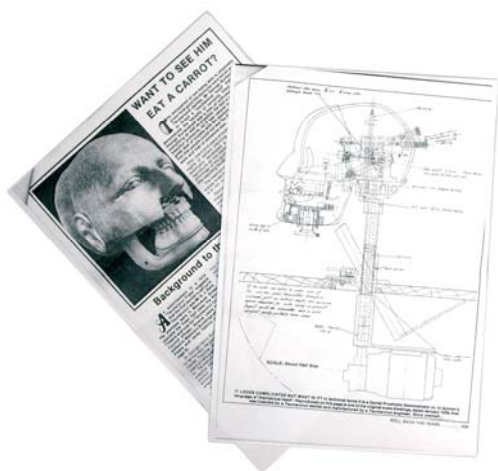
In fact, once perfected the jaw could even be customised to match the characteristics of a particular demographic. Says Bronlund: "Children have pointy teeth. As you age your teeth flatten with wear. The pipe dream is that way down the track you will be able to say 'I want to create a product for six-to-10-year-old Korean kids' and customise the jaw to match. Or, as the baby boomers hit sixties and seventies with their teeth in varying states of repair, you will be able to use the jaw to explore how reduced dentition affects food choice."

How far off is that perfect jaw? Still some way. Lacking are a palate-and-cheeks equivalent to hold the food in the jaw as it is chewed, a tongue to sort the food, and – although the current prototype can be programmed to various speed, force and direction settings – the artificial intelligence that will allow the jaw to self-regulate its behaviour according to feedback.

Creating a simple substitute for a palate and cheeks shouldn't be that difficult says Dr Bronlund, and in 2005, Dr Xu, Dr Bronlund and Dr Kylie Foster, a food engineering lecturer specialising in human chewing behaviour, received a grant to explore the development of an intelligent robotic jaw, that is, one that will know how to chew by responding to its own sensors rather than through human instruction.

"We want to develop a knowledge-based system, one that involves jaws, teeth, muscles, all those

things that participate in the chewing process,” says Xu. “We need to use an artificial intelligence language to formalise how all these parts contribute to the entire process. If we begin research right now we may have the real working robot in five-to-10 years.”



A 3-D articulograph – a more advanced version of the apparatus originally used in France, is now available in Massey to provide more human chewing trajectory information to help the jaw simulate the behaviour of its human counterpart.

So far, the chewing trajectories for some typical foods (e.g. peanut and cereal bar) have been recorded and successfully generated by the chewing robot. The research team has fabricated a mechanism to retain the boluses produced by the chewing process – a further step toward incorporating a digestion system with the device.

The development of a tongue is more difficult, says Dr Xu, though he and Dr Bronlund are trying to secure funding to develop one.

“A tongue is a flexible structure. Theoretically that requires an infinite number of degrees of freedom. Of course we’ll be working on simplified models.”

Has all this attention to the way people eat made Xu self-conscious about his own eating habits? “I have started to think about how many chews are required for different foods,” he confesses. “I’ve also started to think about how many chews I make on one side versus the other.”

He smiles: “Overall, my chewing is quite balanced.”

## ACRA'07 Report

*Bruce MacDonald, University of Auckland*

The 9th Australasian Conference on Robotics and Automation was held on 10-12 December at the University of Queensland's St Lucia campus, Brisbane, Australia. The sessions were all held at the newly built Queensland Brain Institute. The technical sessions were spread over three days, in one single stream, so that everyone came to know each other well and much lively discussion ensued. Sessions included papers in the following areas of robotics: biorobotics, terrestrial robot vision, navigation, industrial robotics, aerial robot vision, artificial intelligence, control systems, sensors & sensing, machine vision, human robot interaction. The AGM of the Australian Robotics and Automation Association was held at midday on Friday the 12th. The social programme included an informal dinner on the first night, and a more formal banquet the second night.

Full papers were submitted and each was reviewed by at least three members of the programme committee of 27 researchers from Australia and New Zealand. 50 of the 62 submitted papers were accepted and presented. Some 70 people attended the conference. The standard of papers was high, as it usually is, attesting to the range and quality of robotics research in Australasia.

From New Zealand, Karl Stol and I attended and presented, along with two final year students Han Wang and Sungkono Surya Tjahyono from the University of Auckland; Praneel Chand presented his work (supervised by Dale Carnegie at Victoria University of Wellington). Two staff from a local Auckland robotics company also attended. The full papers and programme are distributed at the conference in CD form, and also published on the ARAA web site:

<http://www.araa.asn.au/acra/acra2007/>

CDs are available from the ARAA.

At the AGM, the association agreed to consider changing its name from the Australian Robotics and Automation Association to include NZ, using "Australasian" instead of Australian. The association is also considering options for the addition of "Mechatronics" to the name; suggestions were called for. People were interested to hear about ROMENZ and there may be opportunities for ROMENZ to work together with ARAA.

A mechatronics discipline leaders meeting across Australia and New Zealand was also held on the

last day of the conference. A recent survey of mechatronics programme contents was presented, with a view to some kinds of standardization. There was also discussion of industry needs in mechatronics.

The next ACRA conference will take place in Canberra, 3-5 December, 2008. Details will appear at: <http://www.araa.asn.au/acra/>

## ISO STANDARDS FOR SERVICE ROBOTS

*G. S. Virk<sup>\*</sup>, S Moon<sup>†</sup>, R Gelin<sup>§</sup>*

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The focus of robotic systems is changing, from developing manufacturing robots for restricted industrial environments, to producing service robots for a wide range of applications and environments. The traditional robot industry is still focussed on manufacturing applications and does not have staff able to formulate the specifications for the new service robots as the concepts are new and not yet well defined. The situation is more at the research level than at product development. In view of this, it is important to engage the robot research community because this new sector of robotic applications needs to be properly developed and supported in order to grow. It is clear that, as this new sector develops, new robot standardization issues will emerge, and they will need to be addressed if the new area of service robots is to be properly supported. However, getting robots out of the factory and into our homes, and work places, to provide the “service” is not a trivial task. Current robots are “industrial machines”, designed to be used while keeping at a safe distance from humans. In addition they require skilled staff to operate them, using complex interfaces.

The emergence of new service robots has been noticed by many organisations throughout the world, and steps have been taken to support the new developments. International robot standardization has traditionally been the responsibility of ISO (International Organization for Standardization, see [www.iso.org](http://www.iso.org)) under TC184/ SC2. Until 2006, these ISO robot standardization activities focussed on robots in industrial environments; this was reflected in the title for sub-committee 2 (SC2) which was “Robots in industrial environments”. In 2006 the title of SC2 was changed to “Robots and robotic devices” to remove the focus on industrial

environments, and its scope was also widened. The new SC2 scope is the following:

“Standardization in the field of automatically controlled, reprogrammable, manipulating robots and robotic devices, programmable in more than one axis and either fixed in place or mobile. (Excluded: toys and military applications)”.

In making this change in title and scope, new ISO robot standardization activities have been proposed; these include the setting up of the following group and teams:

- An Advisory Group (AG1) on Service robots (Chair: Prof S Moon)

- A Project Team (PT2) on Robots in personal care (Chair: Prof GS Virk)

- A Project Team (PT3) on Vocabulary on robots and robotic devices (Chair: R Gelin)

These include robot experts from Japan, South Korea, UK, USA, France, Germany, Hungary, Sweden and Switzerland. The overall activities are presented in this article, to disseminate the progress of the standardization work, so that the robot community can be properly engaged in these important developments to widen the application base of robots and robotic devices; further details are given in a paper to be presented at CLAWAR’08 (see [www.isr.uc.pt/clawar2008/](http://www.isr.uc.pt/clawar2008/)).

The latest meetings were held in Wellington, New Zealand during February 2008, and progressed the work of the group and the teams. Brief details of this work are presented next.

PT2 has been working to develop a safety standard for personal care robots. The key distinction of this sector is that close human-robot interactions are planned, and are in fact essential in the new robots that are needed. The safety standard being developed will be in two parts. Part 1 will present the safety standard for non-invasive personal robots, and Part 2 will consider issues of invasive personal care such as those produced for surgery. Most of the work to date has focussed on the non-invasive case, and a detailed structure for the new standard has been developed, based on a risk assessment approach.

The invasive personal care safety standard work has also commenced, and an ISO TC184/SC2/PT2 Workshop on Service robots in surgery and medicine has been arranged, to be held at CARS 2008 on 28 June 2008 (Computer assisted radiology and surgery, 22nd International Congress and Exhibition, 25-28 June 2008, Barcelona, Spain, [www.cars-int.org](http://www.cars-int.org)). This is a major medical conference, and the intention of the ISO PT2 Workshop is to bring together engineers and medical practitioners to formulate the requirements necessary for the invasive personal care robots. The programme for the Workshop is as follows:



•Service robotics - Prof Seungbin Moon, Sejong Univ, Korea

•The changing robot vocabulary - Rodolphe Gelin, CEA-LIST, France

•Robots in personal care - Prof Gurvinder S Virk, CLAWAR Ltd, UK

•Medical/surgical robotics in Germany - Dr Martin Haegele/Dr Jan Stallkam, Fraunhofer-IPA

•Medical robot research in UK - Dr MO Tokhi (Sheff), Dr K Bouazza-Marouf, LUT, UK

•Medical robot research in Korea - Prof Soon-Geul Lee, Kyung Hee Univ, Korea

•Medical robot research in USA - Dr Abul Azad, Northern Illinois Univ, USA

•Medical robot research in Japan - Dr Kiyoyuki Chinzei, AIST, Japan

•Structured discussion - Panel (robot experts, surgeons, regulatory bodies, etc).

PT3 is extending the current robot vocabulary that only applies to “industrial robots” as defined by ISO. In fact there is no official ISO definition of a “robot”, and the closest definition is of an “industrial robot” which is presented in ISO 8373(1994) [8]) as: “An industrial robot is an automatically controlled, reprogrammable, multipurpose manipulator, programmable in three or more axes which may be either fixed in place or mobile for use in industrial automation applications.” It is clear that this definition is rather dated, and new definitions are needed to make them more appropriate for the new service robotics sector. Some of the key definitions have been formulated, but have yet to be formally accepted by the national balloting process that is taken in adopting ISO standards. Some of these definitions are as follows:

•Robot: Reprogrammable or autonomous mechanical system moving in its environment, programmable in more than one axis.

•Robotic device: Mechanism moving in its environment, programmable in one axis, with a degree of autonomy.

•Industrial Robot: A robot for use in industrial automation applications. Examples include Manipulators for welding, painting, cutting, assembling, Mobile bases in industrial automation applications, Mobile Manipulators in industrial automation applications, Assistive robots in industrial automation applications, etc.

The Advisory Group on service robots is investigating the new emerging developments in service robotics, and has put forward proposals for new project teams to perform the detailed developments for the standardization issues. The group has already proposed the setting up of the two project teams, PT2 and PT3, on personal care robots and the vocabulary discussed above. The

current issues being addressed are as follows:

- Ethical issues in robotics
- Farm animal handling robots
- Performance of service robots
- Robot modularity

It is clear that, from these and other activities, robotics is changing and new rules and regulations are needed to continue the growth of the new types of robots emerging in the non-traditional sectors. The commercial activities in these new areas are not yet mature enough to support these developments. It is essential that the research community engages fully within these regulatory activities so that sound and fully acceptable protocols will be formulated and accepted by the international community. The authors would, therefore, like to invite all the stakeholders within the robotics community to play their full role in developing these new robot sectors. For further details, contact the authors.



CogSys  
Cognitive Systems



European Commission: FP6 – <http://www.cordis.lu/ist/> - IST  
Cognitive Systems - ContractN°004690

## SPARK:

**Spatial-temporal Patterns for Action-oriented  
perception in Roving robots**

[www.spark.diees.unict.it](http://www.spark.diees.unict.it)

*P. Arena, L. Patanè, D. Lombardo, S. De Fiore  
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In the last few years a growing interest has been paid to the study and design of complex adaptive intelligent systems for the enhancement of perceptual capabilities in Robotics. Research in this direction has been much helped by the constitution of multidisciplinary teams. Here Neurobiologists worked together with Engineers and Physicians to elaborate biologically inspired theories that could also have an impact on the advancement of science and technology. Among the main topics of research in this field, one of the most promising is the so-called action-oriented perception: in fact, perception is tightly connected, from one side, to the incoming sensory signals that account for the environment state, and on the other side, to the motor outcome of the agent that actively interacts with the environment, affecting back, in a closed loop manner, the sensor input.

Typical example of how, even simple animals, efficiently exploit sensory signals, is phonotaxis in crickets: they use this ancient sense more than all the others, to perform a vital function, like mating. Also motion in living systems is derived from highly organised neural networks driving limbs and other parts of the body, in response to sensory inputs. A huge number of muscular cells are controlled in real time and in an adaptive fashion. Biological locomotion generation and control patterns were demonstrated to be efficiently modelled by using the paradigm of the Central Pattern Generator (CPG) as well as the decentralised control approach (Walknet). In locomotion, different and differently specialised neuronal assemblies behave in a self-organised fashion in such a way that, as a consequence of certain stimuli, particular patterns of neural activity arise, which are suitably sent to peripheral fibres to generate rhythmic activities of leg motion and control. Recent results have also shown that nonlinear and complex dynamics in cellular circuits and systems can efficiently model both sensing and locomotion. After analyzing and being involved in such topics, researchers from various scientific fields and from different European Laboratories came up with the same idea to glue their effort to try to progress from sensing and locomotion modelling, to perception.

The SPARK project was aimed at addressing such topics. This project was funded by the European Commission, under the Cognitive Systems call of the 6th Framework. SPARK constituted six partners: the University of Catania, Dipartimento di Ingegneria Elettrica Elettronica e dei Sistemi - DIEES (coordinator), the Instituto Pluridisciplinar of the Universidad de Complutense de Madrid (IP-UCM), the University of Edinburgh, Institute of Perception Action and Behaviour (UNIED), the University of Bielefeld, Institute for Biological Cybernetics (UNIBI), and two SMEs, ANALOGIC Computers (Hungary) and ANAFOCUS (Spain).

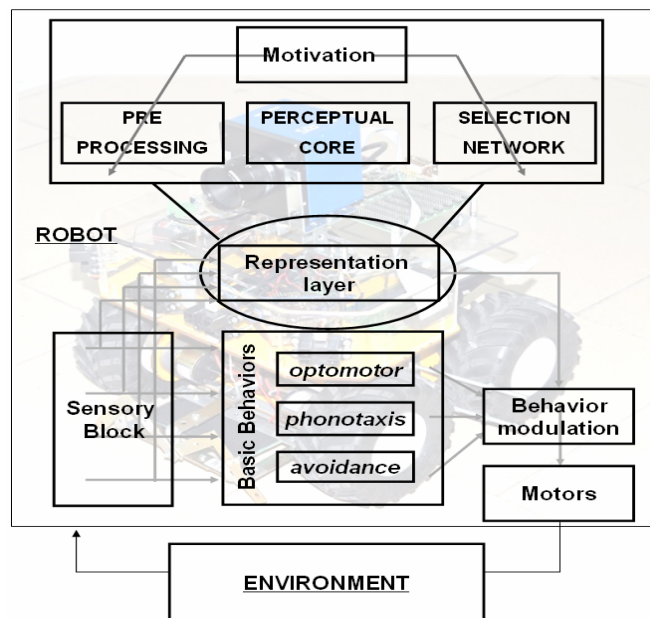
The aim of the SPARK Project was to introduce completely new sensing-perceiving-moving artifacts inspired by the basic principles of living systems and based on the concept of "self-organization". Sensors were treated as devices processing signals distributed in space and also showing non linear time dynamics. Perception was formulated as an emergent phenomenon in spatio-temporal pattern forming architecture, determined by information deriving from sensors and directly influencing the particular associated motor behaviour. The whole methodology was implemented in a new architecture, a Spatial-temporal array computer based structure, providing a new paradigm for active perception based on

principles borrowed from psychology, synergetics, artificial intelligence and nonlinear dynamical systems theory.

The project had high challenging targets that were successfully reached.

The active collaboration resulted in the introduction of a new general model for action-oriented perception.

This structure is schematically reported in Fig.1.



**Fig.1 – SPARK cognitive architecture**

This is a hierarchical structure, which takes inspiration from previous work on environmentally mediated perception, but enhances the existing models in several aspects, reflecting each individual partner's expertise. In particular, primary attention was given to the integration of vision into the general perception scheme; due to the complexity of visual sensing and the difficulty of extracting relevant aspects for real time perception/action purposes, this issue is not often evaluated. The availability of a visual hardware chip from ANAFOCUS (the Eye-Ris 1.2 visual system), able to extract in real time several different and concurrent salient features, allows visual information to be efficiently processed and fused with other sensor stimuli. The expertise of UNIED on sound perception in insects was very useful to efficiently process sound signals, while the Walknet architecture for decentralised locomotion control from UNIBI allowed the tactile sensory structure and robot leg control to be included directly within the perception-action scheme. Referring to Fig. 1, parallel pre-cognitive behaviours (basic behaviours), acting as hardwired systems, cooperate to provide suitable actions to drive the robot from the very beginning of its navigation. Higher structures provide an ever increasing level of adaptation, including plasticity and learning. In

particular a proto-cognitive correlation layer is devoted to detect time varying causal correlations among the basic behaviours so as to learn to anticipate one behaviour through another. This layer was defined starting from several different views by UNIED, IP-UCM and DIEES during full weeks of joint work at the University of Catania.

A further layer provides “Representations” of the environment. These are conceived as emergent dynamical flows in complex nonlinear dynamical cellular systems, under the form of Turing Patterns [1]. These provide an abstract and concise representation of the environment as an emerging pattern, whose codified version is used to learn, without supervision, the suitable modulation of the proto-cognitive behaviours of the lower levels. The highest level, called “motivation layer” hosts a Reward function (RF), which defines the overall mission for the robot. During learning, a series of punishments and rewards guides learning of the actions to be associated to the emerging pattern in the representation layer. The RF also modulates the input to the Representation layer, in order to plastically modify the basics of attraction of the emerging patterns, further enhancing the role of the representation layer as a kind of mirror of the various environment conditions. Further memory models save successful sequences of modulated behaviours for future exploitation.



**Fig.2: One of the SPARK brainstorming weeks**

The technical objectives were moving artefacts, like those ones depicted in the following figures. All of them are autonomous. Robotic research in the design and realisation of such prototypes was not focused only to produce new robots as such: these are considered as test beds to assess and evaluate the suitability of the perceptual architectures designed in the previous phase. This leads to the production of different types of robots, as a function of the particular perceptual module to test. All of the prototypes are able to actively interact with the environment. They were designed and realised in order to show active integration of sensor stimuli, creation of an iconic, abstract and concise representation of the environment under the

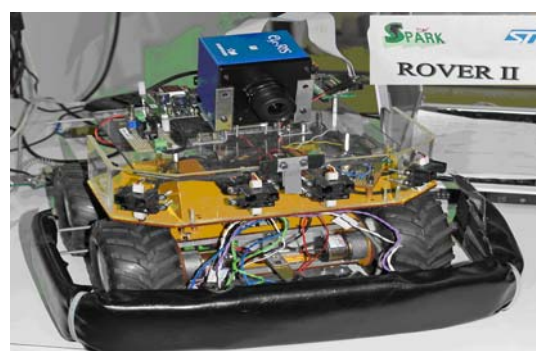
form of a dynamically emergent pattern and generation of a sequence of proper motor actions to reach a pre-specified target.

Gregor III, reported in Fig.3, was conceived to be a high efficient testbed for the study of complex locomotion control strategies, like the Walknet network. It has a sprawled structure and roughly reminds of a cockroach. It has a huge payload with respect to the other similar hexapod robots: this enables it to have about one hour of full autonomy. It is endowed with contact sensors for the low level locomotion control, distance sensor for navigation and the Eye-Ris visual microprocessor for the real time capability of performing complex visual image and video processing, to be used for the perceptual routines. Acoustic sensors and a dedicated hardware board for the implementation of the phonotaxis behavior complete the sensor network. All the perceptual routines are embedded within a custom made board, the SPARK 1.0 board, hosting a powerful Altera Stratix 2 FPGA, a great amount of memory on board and a huge number of I/O pins, for handling the sensor and actuator network.



**Fig.3: Gregor III**

The exploration of new methodologies for action oriented perception in the early stage of formulation, often leads to very complex structures: if the aim of the research, like in SPARK, is the direct robotic implementation, it is not feasible to test the perceptual algorithms on yet more complex robots, like legged ones. It is more suitable to perform the first tests on robust and easier to control robots, like wheeled ones.



**Fig.4: ROVER II**



In Fig. 4 the Rover II robot, designed and realised for this aim, is depicted. Rover II has infrared (distance) and contact sensors, useful for low level navigation, as well as for the testing of anticipation [2] and perceptual routines. It is endowed with the Eye-Ris 1.2 as well as the circuits and sensors for phonotaxis, and a digital compass to explore the high level representation layer in action, while modulating the basic behaviors, like avoidance, phonotaxis and optomotor reflexes. The low level motion control architecture was realised by means of an STR730 microcontroller, from ST Microelectronics, with the possibility to implement a high performance torque control on the four powerful DC motors that implement motion.

Finally, among the most relevant prototypes built within the project, we cannot forget the MINIHEx, a mini hexapod of 20 cm length, completely autonomous, endowed with an analog VLSI circuit implementing a CPG for the implementation of the locomotion control routines. Infrared sensors are also included for the implementation of the basic navigation skills. MINIHEx was efficiently used for the testing of visual navigation routines, implemented on the Eye-Ris of the Rover II, to perform a prey-predator game, where the Rover II had to hunt the MINIHEx in a cluttered environment with obstacles. MINIHEx is envisaged to be used, together with other similar robots, to test swarm experiments in the near future.



**Fig. 5 MINIHEx**

Multimedia material, where to find videos and further explanation on the topics mentioned here, is available on the web page [2].

The introduction of the new architecture for action-oriented perception, based on principles borrowed by insect neural principles, nonlinear dynamics and complex system theory, was implemented in these robotic structures, leading to some results that are really encouraging for the future exploitation, further assessment, optimization and generalization of the SPARK architecture to different and more complex robots. These are the main topics upon which a new EC funded project

SPARK II will develop during the next three years.

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## Omni-directional vision system for humanitarian demining

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### 1. Introduction

Humanitarian demining [1-2] missions require the use of robust systems such as efficient mobile robots and improved sensors [3-7]. This application domain involves performing tasks in non structured scenarios and dynamically changing environments. This contribution presents a new approach based on omni-directional vision systems for terrain description. Computer vision systems are widely used in robotic applications. However, conventional video cameras have limited a field of vision which restricts their use for many applications. For example, mobile robots often require a full 360° view of their environment, in order to perform navigational tasks such localizing within the environment, identifying landmarks and determining free paths in which to move. Omni-directional sensors allow the capture of a much wider field of view; providing panoramic images 360° around the robot. Certain techniques have been developed for acquiring panoramic images. This work shows a direct application of a low-cost catadioptric omni-directional vision sensor on-board a six-legged robot, intended for antipersonnel landmine localization, to improve efficiency of involved tasks in automated detection and removal operations.

### 2. The DYLEMA project

The DYLEMA project is devoted to the configuration of a humanitarian de-mining system consisting of a sensor head, a scanning manipulator and a mobile platform based on a hexapod walking robot (see Figure 1) [7]. The sensor head has a commercial mine-detecting set, customised with a ground-tracking set, to adapt the head to ground

irregularities. This ground tracking set provides adequate information to maintain the manipulator's end-effector at a desired height/attitude above ground. To do this, the manipulator has to track the surface whilst moving the sensor head, and also has to avoid obstacles in the path of the sensor head, such as big stones, bushes, trees etc. The sensor head information is also used by the system controller to steer the mobile robot during mine detection missions.

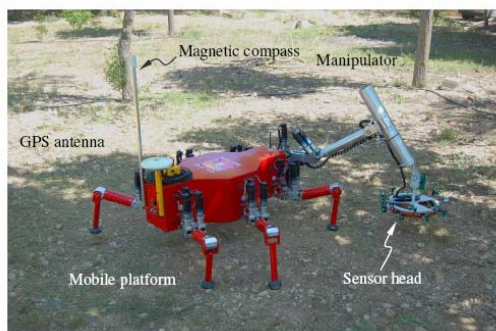


Figure 1: DYLEMA configuration.

The DYLEMA project focuses on the development of robotic techniques to help detect and locate potential alarms. After a suspect object is detected, its location must be recorded in the system database for further analysis and possible deactivation. Additionally, the DYLEMA project includes research in methods of complete coverage of unstructured environments for mobile robot navigation [8] and sensor integration and control for scanning activities [9].

### 3. Omni-directional vision system

Over the years, researchers in several engineering fields such as applied optics, computer vision, and robotics, has presented remarkable works related to omni-directional cameras and their applications [10]. The standard cameras typically have a constrained field of view ( $\sim 30^\circ$ – $60^\circ$ ) and are therefore adequate for observing small local areas. However, many applications require or benefit from observing wider areas, which is not possible with a direct camera. For example, mobile robots often require a full  $360^\circ$  view of their environment in order to perform navigational tasks such identifying landmarks, localizing within the environment, and determining free paths in which to move. In our case it is also required to combine these computations with landmine detection tasks.

The proposed omni-directional sensor is based on providing a wide field of view. It consists of a camera and a hyperbolic mirror above, leading to a catadioptric sensor. The 3-dimensional data processing is based on the hypothesis of satisfying the single effective viewpoint constraint [11].

Although obtained resolution is lower than the original image, the wide view angle benefits the estimation algorithms stabilizing for ego-motion and so the rotations and translations can be easily distinguished. Starting with two panoramic images it is possible to bring out a surrounding scene area, by means of  $360^\circ$  view angle around the camera.

### 4. Experimentation and results

Silo6 six-legged robot was equipped with a catadioptric hyperbolic vision system. An omni-directional image acquired by our system is shown in Figure 2, along with its corresponding panoramic image. Note that both images are distorting from our point of view; however using omni-directional theory it is straightforward to calculate this deformation angle and introduce it in the system.



Figure 2: Omni-directional and panoramic views.

The omni-directional sensor prototype was tested on-board six-legged robot Silo6, a sequence acquired by the system is shown in Figure 3, where corresponding entities do not vanish due to limited field of view (enclosed by trapezoid).

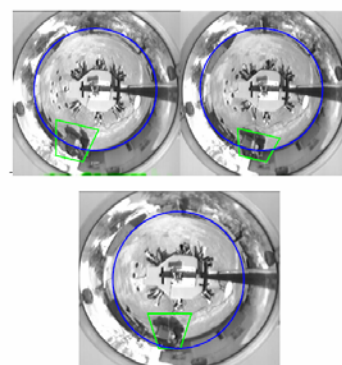


Figure 3: Sequence of catadioptric system on-board Silo6. Small black "circles" ahead of the robot are "dummy" mines.

The displacements of such entities vary considerably with different kind of motion. With this system it is possible to detect objects around the robot by only acquiring a single image per time. The terrain area around the robot can be easily separated from the peripheral area, such as trees, bushes stones, and moving objects.

The system is capable of detecting several



obstacles, and static or moving objects. It is possible to apply image processing techniques (e.g. optical flow) for segmenting these objects and avoiding them. Also the system is able to track the trajectory of the manipulator (Figure 4) and to use vision to correct its movement, especially in situations where two objects are close up and the distance between them is smaller than the sensor head diameter.

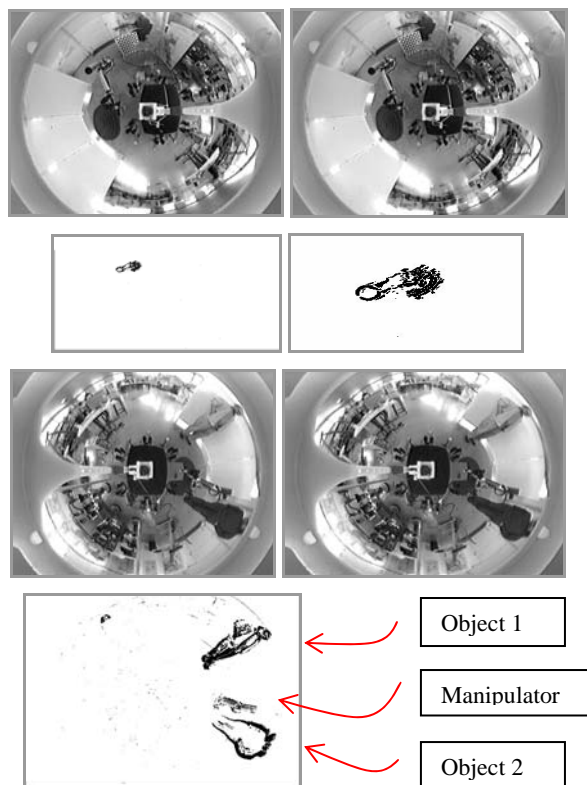


Figure 4: Sequence of scanning manipulator movement and objects detection.

Another important issue is the capability to observe with a single image, the environment and the robot itself. The area covered by the image includes the space between the scanning system manipulator and the robot. This system can also observe a 360° view for tele-operation applications, increasing the safety of the operator and the robot itself.

## 6. Conclusions

The removal of antipersonnel landmines is a global issue. This work presented the possibility of designing a low-cost system based on an omnidirectional sensor to improve the efficiency of humanitarian de-mining tasks. Because these tasks require devices that can automate the location of unexploded ordnance, it would be beneficial to use robotic systems capable of carrying scanning sensors over infested fields. The ongoing prototype has very useful features and can benefit several tasks involved in humanitarian demining missions. The robotic system can respond in advance, i.e. to obstacles situated in a distance larger than the manipulator range. The system is capable of

making online corrections of its trajectory. Another important benefit is the efficiency of a complete coverage of a minefield wider area, since the system has previous knowledge of the terrain and its obstacles before travelling it.

## Acknowledgements

DYLEMA project was funded by the Spanish Ministry of Education and Science through grant DIP2004-05824. This work was supported in part by Consejería de Educación of Comunidad de Madrid under grant RoboCity2030 S-0505/DPI/0176. This work is also funded by Comunidad de Madrid through an FPI fellowship.

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# The Robotics Research Lab

## University of Kaiserslautern

Prof. Dr. Karsten Berns

<http://rrlab.informatik.uni-kl.de>

Since 2003 the Robotics Research Lab has developed complex biologically motivated robotic systems. The methodological research is carried out using algorithmic approaches as well as mobile robot control architectures.

### Areas of Research and Development

- Mobile Service Robotics
- Sensor and Actor Technology
- Walking Machines
- Embedded Systems
- Mechanical Design and CAD
- Robot Control Software Architecture
- Computer Vision
- Human Machine Interaction
- Climbing Robots

The goal of this project is the development of a wheel driven service robot named CROMSCI, which can cling to a wall via negative pressure. It has to be controllable by a person, but should evade obstacles autonomously, and inspect the concrete building area-wide. To demonstrate the performance of the system, a bridge pylon is to be inspected by the robot.

Sub-goals of the project are the under-inflation chambers, including seals and valves, a reliable control architecture and sensor-based perception of the environmental conditions.



CROMSCI

### Dynamic Biped Locomotion

Control of dynamic biped locomotion is still an unsolved problem in robotics. Our research approaches this topic using a more biologically inspired control concept. This way, properties such as elasticity, and the natural dynamics of the system can be exploited. The control is tested in a physical simulation environment.

### Human-Robot Interaction

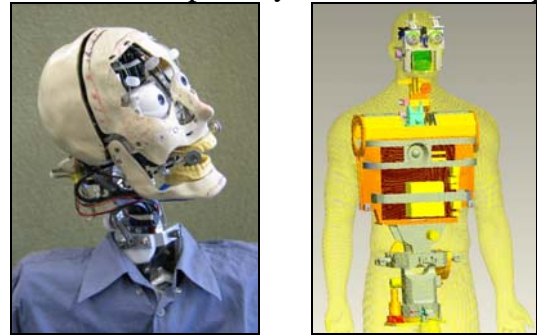
The interaction between humans and robots is often limited to input devices such as keyboard and mouse. Future applications of mobile robots require a more natural interaction mechanism. Service robots, which coexist with humans in a common environment, should be controllable without the requirement specific technical knowledge by the

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controller.

The communication between humans is not limited to speech. In fact it is a complex summary of speech, gestures, mimicry and various emotional expressions. Therefore it is necessary to focus on these aspects of natural interaction with a view to integrating them into a robotic system.

The humanoid robot, ROMAN, has been designed for research, using natural interactions. Equipped with multiple sensors, such cameras and microphones, as well as a complex actuation system with over twenty degrees of freedom, the robot is able to realize all primary communication aspects.



ROMAN

### Off-Road Robotics

Today the world is facing an increasing frequency of natural disasters, large-scale accidents and terrorism.

Unmanned vehicles could patrol frontiers, guard industrial estates, take routine measurements in predefined areas, fulfill reconnaissance tasks in hostile environments, or assist in clearance duties in cases of severe accidents or natural disasters.

To meet future demands in crises prevention, the Robotics Research Lab has formulated the development of an entirely autonomous vehicle for rough and vegetated off-road terrain.



RAVON

### Indoor Robotics

In the area of indoor robotics we address localisation and mapping, object detection, and human-robot interaction.

Furthermore, the Robotics Research Lab participates in an assisted living project, where a small mobile unit is integrated into a living environment. Scenarios are autonomous transport services, tele-operated emergency evaluation and human to human communication enhancement.



MARVIN



ARTOS

## Tools

Tool for the development of elaborate machines, innovative computer architectures, and electronic concepts are also studied at the Robotic Research Laboratory. Furthermore, tools for adequate support of the development process over the full life-cycle of robotic systems are implemented. These are published on the RRLib webpage (<http://rrlib.informatik.uni-kl.de>), as a compendium of best practices and tools for the robotics community.

# A gateway to the engineering world -- annual robotic car competition in Massey University

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At the end of May every year, there is an annual robotic car competition in the Massey University Wellington campus. The event is unique in that the robots are designed and built by the first year B.Eng students, as part of their course work.

As a departure from traditional B.Eng training, where the first year is dedicated to fundamental courses such as mathematics and physics, Massey's engineering students are also required to undertake engineering projects on campus. The robotic car competition is one of the favourite projects among the students.



Previous winners

In the competition, the students demonstrate their robots' capabilities in speeding, climbing a ramp, negotiating a maze and following a spiral circuit. It takes about one month for a project team (two or three students) to make a robot, within the budget of \$50. They also keep the blogs of their progress on the school's web site (<http://www-ist.massey.ac.nz/143151/>).

The enthusiasm and creativity demonstrated by the students in this project is amazing. They are really enjoying, and are proud of, their first experience of working with an electronic circuit and mechanical structure. One student, in last year's competition commented, "It was a great learning curve and inspiration for me. My favourite part of the project was just seeing what people came up with at the end, and seeing all the different and creative angles".



Line following robotic car

This year's competition will be held on 29 May, 2008. Many students are now working day and night to make their robots ready for the big event. We wish them good luck!



Hill climbing robotic car



# CALENDAR OF EVENTS

<b>2008 IEEE Conference on Robotics, Automation and Mechatronics (RAM)</b> 3-6 June 2008 Chengdu, China <a href="http://www.cis-ram.org">http://www.cis-ram.org</a>	<b>IERA'08: IFR/IEEE Industry Forum on Innovation and Entrepreneurship in Robotics and Automation</b> 12 June 2008 Muenchen, Germany <a href="http://www.ieee-ras.org/industrial/iera.php">www.ieee-ras.org/industrial/iera.php</a>	<b>ICIA 2008: IEEE International Conference on Information and Automation</b> 25-27 June 2008 Jeju Island Republic of Korea <a href="http://cnsi.kaist.ac.kr/ICIA2007/">http://cnsi.kaist.ac.kr/ICIA2007/</a>
<b>RSS 2008: Robotics: Science and Systems</b> 25-28 June 2008 Zurich, Switzerland <a href="http://www.roboticsconference.org/">www.roboticsconference.org/</a>	<b>CITSA 2008: The 5<sup>th</sup> Int Conf on Cybernetics and Information Technologies, Systems and Applications</b> 29 June-2 July 2008 Orlando, Florida, USA <a href="http://www.infocybereng.org/imeti2008/">www.infocybereng.org/imeti2008/</a>	<b>AIM 2008: IEEE/ASME International Conference on Advanced Intelligent Mechatronics</b> 2-5 July 2008 Xi'an, China <a href="http://www.aim2008.info/">www.aim2008.info/</a>
<b>ROMANSY'08: 17<sup>th</sup> CISM-IFTOMM Symposium on Robot Design, Dynamics and Control</b> 5-9 July 2008 Tokyo, Japan <a href="http://www.romansy2008.org/">www.romansy2008.org/</a>	<b>17th IFAC World Congress</b> 6-11 July, 2008 Seoul, Korea <a href="http://www.ifac2008.org/">www.ifac2008.org/</a>	<b>ARCS 08: International Conference on Automation, Robotics and Control Systems</b> 7-10 July 2008 Orlando, Florida, USA <a href="http://www.promoterresearch.org/2008/arcs/">www.promoterresearch.org/2008/arcs/</a>
<b>RoboCup2008 : The 12<sup>th</sup> RoboCup International Competitions and Conferences</b> 14-20 July 2008 Suzhou, China <a href="http://www.robocup.org/games/08Suzhou/340.html">www.robocup.org/games/08Suzhou/340.html</a>	<b>RO-MAN 2008: IEEE Int Symp on Robot and Human Interactive Communication</b> 1-3 August 2008 Muenchen, Germany <a href="http://www.lsr.ei.tum.de/ro-man2008/Downloads/cfp_roman08.pdf">www.lsr.ei.tum.de/ro-man2008/Downloads/cfp_roman08.pdf</a>	<b>ICMA 2008: IEEE International Conference on Mechatronics and Automation</b> 5-8 August 2008 Takamatsu, Japan <a href="http://www.icma2008.org/">www.icma2008.org/</a>
<b>SICE 2008: Society for Instrumentation and Control Engineering Annual Conference</b> 20-22 August 2008 Chofu, Japan <a href="http://www.sice.or.jp/sice2008/">www.sice.or.jp/sice2008/</a>	<b>MFI 2008: Multisensor Fusion and Integration</b> 20-22 August 2008 Seoul, Republic of Korea <a href="http://www.mfi2008.org/">www.mfi2008.org/</a>	<b>IEEE-CASE 2008: 4<sup>th</sup> IEEE Int Conf on Automation Science and Engineering</b> 23-26 August 2008 Washington DC, USA <a href="http://www.ieee-case.org/">www.ieee-case.org/</a>
<b>CLAWAR 2008</b> 8-10 September 2008 Coimbra, Portugal <a href="http://www.clawar.org/clawar2008">www.clawar.org/clawar2008</a>	<b>IROS 2008: The 2008 IEEE/RSJ Int Conf on Intelligent Robots and Systems</b> 22-26 September 2008 The Acropolis Convention Center, Nice, France <a href="http://www.iros.org/">www.iros.org/</a>	<b>2008 International Conference on Control, Automation and Systems (ICCAS)</b> 14-17 October 2008 Seoul, South Korea <a href="http://www.iccas.org">http://www.iccas.org</a>
<b>2008 International Conference on Intelligent Robotics and Applications</b> 15-17 October, 2008 Wuhan, China <a href="http://www.yahuang.org/main.htm">www.yahuang.org/main.htm</a>	<b>IECON 2008 – 34<sup>th</sup> Annual Conference of IEEE Industrial Electronics</b> 10-13 November 2008 Florida Hotel & Conference Centre, Orlando, Florida <a href="http://iecon2008.auburn.edu">http://iecon2008.auburn.edu</a>	<b>2008 International Conference on Computer Engineering &amp; Systems (ICCES)</b> 25-27 November 2008 Ain Shams University Guest House, Cairo, Egypt <a href="http://www.iceec.org">http://www.iceec.org</a>
<b>15th International Conference on Mechatronics and Machine Vision in Practice, 2008 (M2VIP,2008)</b> 2-4 Dec 2008 Massey University, Auckland, New Zealand <a href="http://www.m2vip.com">www.m2vip.com</a> <a href="http://www.massey.ac.nz/~wlxu/m2vip">www.massey.ac.nz/~wlxu/m2vip</a>	<b>ICARCV: 10<sup>th</sup> Int Conf on Control, Automation, Robotics and Vision</b> 17-20 December 2008 Hanoi, Vietnam <a href="http://www.icarcv.org/2008/">www.icarcv.org/2008/</a>	<b>4th International Conference on Autonomous Robots and Agents (ICARA)</b> 10-12 February 2009 Wellington, New Zealand <a href="http://icara.massey.ac.nz">http://icara.massey.ac.nz</a>



# CLAWAR'2008

11<sup>th</sup> International Conference on Climbing and Walking  
Robots and the Support Technologies for Mobile Machines  
08 – 10 September, 2008, Coimbra, Portugal



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## Announcement and Call for Participation:

Robotics is an exciting field in engineering and natural sciences. Robotics has already made important widespread contributions and impact in industrial robots for tasks such as assembly, welding, painting, and material handling. In parallel, we have also witnessed the emergence of special service robots which perform valuable jobs, in new environments such as search and rescue, surveillance, exploration and security missions as well as provide assistance to a variety of users. The emergence of mobile machines, such as the climbing and walking robots, for these missions in un-structured environments, has significantly broadened challenges that must be considered by robotics research.

The purpose of the 11<sup>th</sup> International Conference on Climbing and Walking Robots and the Support Technologies for Mobile Machines (CLAWAR'2008) is to provide a venue where researchers, scientists, engineers and practitioners throughout the world can come together to present and discuss the latest achievements, future challenges and exciting applications for mobile service machines in general, and climbing and walking robots in particular. In order to benefit all participants, and also to maximize the interaction, the technical program of this conference is intentionally tailored to having relatively few parallel tracks. Each track will accommodate peer-reviewed articles, comprising regular and special sessions, dealing with theoretical, experimental and application works. Moreover, the conference will include several keynote lectures and poster sessions.

## Topics of Interest (non-exhaustive list):

### RESEARCH

- Autonomous robots
- Tele-operated robots
- Biologically-inspired systems and solutions
- Innovative design of CLAWAR
- Modelling and simulation of CLAWAR
- Planning and control
- Co-operative robot systems
- Intelligence and learning for CLAWAR
- HMI
- Innovative actuators and power supplies
- Innovative sensors and sensor networks
- Positioning & localization
- Perception and sensor fusion
- Guidance and navigation
- Manipulation and gripping
- Legged locomotion
- Wheeled locomotion
- Hybrid locomotion
- Micro and nano robots
- Tele-presence and virtual reality
- Service robot standards and standardization
- SME robotics

### APPLICATION

- Planetary exploration
- Security
- Emergence rescue operations
- Surveillance
- Reconnaissance
- Education
- Biomedical robots
- Rehabilitation and function restoration
- Petrochemical applications
- Inspection
- Construction
- Entertainment
- Helping the elderly and the disabled
- Manufacturing
- Performing and creative arts robots
- Personal robots
- Robots for domestic environments
- Service robots
- Space robots
- Assistive robots
- Sport and exercise robots

## Important Dates:

Submission of Extended Abstracts: **CLOSED**

Paper Acceptance: 15 May 2008; **CLOSED**

Submission of Final (accepted) Papers: 15 June 2008

Early Bird Registration: 15 June 2008

Author Registration: 30 June 2008

Preliminary Program: 01 July 2008

Conference: 08 – 10 September 2008

For further details visit:

<http://www.isr.uc.pt/clawar2008/>

