

CLAWAR News

Issue No. 17

December 2007

The emergence of
service and
assistive robots?

In this issue:

- **CLAWAR 2007 report**
- **Service robots**
- **Standards and/or ethics**
- **Ageing society**
- **RoboCup**
- **Omini-wheeled robots**

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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:

Articles: Technical topics including theoretical, design, development aspects with academic and/or industrial interest. Typically 1000 – 1500 words long.

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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Editorial

Loulin Huang

I am honoured to take over the editorial duty, from Osman Tokhi, for the CLAWAR Newsletter. Dr Tokhi has contributed tremendously to the success of the newsletter in the past years. I feel very lucky to start my work on this issue from the solid foundation paved by Dr Tokhi, and look forward to his continued support as a member of the editorial board in the future.

Service robots have entered our society at a fast pace and with ever increasing momentum. With robots working closer to human beings, and penetrating deeply into our daily activities, many new issues, some of which are beyond the traditional engineering domain, arise. *Gurvinder Virk* and his team carried out a survey to gauge the readiness of the general public to accept the robots as our companions or assistants in a number of different situations. Based on their findings in the survey, questions about the standards and ethics governing the manufacturing, or the operation of, service robots, have been raised. You can read the report of their work in this issue.

The working environment for a service robot holds a higher level of uncertainty than the working environment for a traditional manufacturing robot, and so a greater level of safety and intelligence is required. There is a need to create a standard platform for developing and testing a robot's intelligence before it can be used in real time and live applications. RoboCup is one of the successful initiatives that can be used for this purpose. Using robotic soccer as a standard problem, RoboCup attracts many researchers wishing to demonstrate their robots' performance in the annual event. In this issue, *Zhou Changjiu* introduces the history, the achievements and the future of RoboCup.

Omni-directional driving mechanisms are found in many mobile robots, thanks to their dexterity and constraints conducive for the controller design. It is also a good candidate for the standard modular driving platform for mobile robots. In this issue, *Ioan Doroftei* and his team shared their experience in designing and fabrication of an omni-directional mobile robot built for education purposes.

The 10th CLAWAR 2007 Conference held in Singapore, in July this year, was the first time that the conference had taken place outside of Europe. The conference has proved to be very successful in their venture; the Conference Report has been produced by the organising committee members, led by *Ming Xie*. The report presents the details of CLAWAR 2007 and describes the main activities. The Call for the next event (CLAWAR 2008) to be held in Coimbra, Portugal during 8-10 September 2008 is also presented in this Newsletter. The Newsletter also contains an article by *Bill Warren* on an IET seminar titled "Our Ageing Society – The Challenges of Appropriate Supportive Technology" which was held in London in January 2007.

As usual, a list of the R&D activities in robotics and related areas is listed for your reference in the Calendar of events.

The CLAWAR Association is slowly beginning to develop and a Board of Trustees has been created. This will be defining the activities and policies for the Association and I will report these developments in future issues.

With the New Year just around the corner, may I take this opportunity to wish everyone a happy Year 2008 ahead.

Loulin Huang

CLAWAR 2007 Report

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Overview

The 10th International conference on Climbing and walking robots (CLAWAR 2007) was held from 16-18 July 2007 in Singapore. The opening session began with a speech by the Chair of the School of Mechanical and Aerospace Engineering, Nanyang Technological University, followed by the General Chair's overview of the CLAWAR 2007's technical program, and the CLAWAR Association Chairman's briefing on the history of CLAWAR. The conference was preceded by the inaugural meeting of the Board of Trustees, potential Patrons and observers, of CLAWAR Association on 17 July as shown below.

CLAWAR Association's 1st Trustees Meeting including potential Patrons, and observers

As well as the eighty technical presentations from the corresponding contributed papers, the conference featured the following five plenary talks:

1. Bipedal humanoid robot and its applications, by Professor Atsuo Takanishi
2. Climbing up the wall, by Professor John Billingsley
3. From micro to nano and swarm robots, by Professor Heinz Woern
4. Climbing robots for non-destructive testing:

historical perspective and future trends, by Professor Bryan Bridge

5. A road from walking machines to surgical robots: Digital Mechatronics, by Professor Steven Dubowsky.

Prof Atsuo Takanishi making the opening speech

Delegates enjoying the conference banquet

The conference banquet was held on 17th July, during which CLAWAR 2007 made awards for the four best papers, one of which was sponsored by the Industrial Robot Journal and was delivered by the journal's editor, Dr Clive Loughlin, who also gave a thoughtful speech on "Military Robots" that highlighted the use of robots in military applications and raised questions and ethics of using robot in these applications. He also reminded the audience of the four robot laws:

0. A robot may not harm humanity, or, by inaction, allow humanity to come to harm.
1. A robot may not injure a human being or,

through inaction, allow a human being to come to harm, unless this would violate the Zeroth Law.

2. A robot must obey orders given to it by human beings except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Perhaps we should all remember these fundamental rules in our research activities.

Ken Waldron receiving his prize

3. Award of best paper on walking robots. Won by M. E. Abdallah, and K. J. Waldron; *Stiffness and duty factor models for the design of running bipeds.*
4. Award of best paper on supporting technologies. Won by S. Dubowsky, J. S. Plante, S. Kesner and P. Boston; *A Hopping Mobility Concept For A Rough Terrain Search And Rescue Robot*

Clive Loughlin addressing the conference banquet

Best Paper Awards and Winners

CLAWAR 2007 gave four best paper awards in the following categories:

1. Industrial robot innovation award. Won by J. Shang, B. Bridge, T. Sattar, S. Mondal and A. Brenner; *Development of a climbing robot for inspection of long weld lines.*
2. Award of best paper on climbing robots. Won by N. Elkmann, M. Lucke, T. Krüger and T. Stürze; *Kinematics, sensors and control of the fully automated facade cleaning robot Sirius for the Fraunhofer Headquarters building, Munich.*

Prof Bridge accepting his prize from Dr Loughlin

Steve Dubowsky making his plenary speech

It is worth noting that the conference's international program committee members spent a great deal of effort to complete the assigned reviews promptly. This enabled the proceedings book to be published in time by the World Scientific Publishing Company.

Heinz Woern delivering his plenary paper

Paper submission and technical programme

CLAWAR 2007 attracted 100 submissions, 80 of which were accepted after a formal review process. The eighty technical presentations were grouped into four themes, namely: Climbing robots, Walking robots, Humanoid soccer robots, and Supporting technologies. The four themes were scheduled to run as parallel tracks so as to maximise interaction among the delegates as much as possible. For further details, visit www.clawar.org/clawar2007.

CLAWAR 2007 proceedings

On 18th July, a farewell cocktail reception was held and was well attended by the delegates.

Discussions and networking over coffee break

Dr Liqiong Tang presenting her paper

VIPS at CLAWAR 2007

Active audience participation

In general, the conference's technical sessions have seen a good participation of delegates, and the conference proceedings have also been well perceived by the delegates.

Ming Xie receiving his chairman's plaque

Invitation to CLAWAR 2008

CLAWAR 2008 will be organised in Coimbra, Portugal during 8-10 September 2008. The General Co-chairs of CLAWAR 2008 will be Anibal de Almeida and Lino Marques (see third from left below). Here, we extend the invitation to attend and participate in CLAWAR 2008 to all researchers in robotics and look forward to meeting old friends in Coimbra as well as making new ones.

Past and future CLAWAR conference chairs

Standards and/or ethics for service robots?

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(re-produced from the Ethics of human interaction with robotic, bionic and AI Systems: Concepts & Policies Workshop, Naples, 17-18 Oct 06)

1. Introduction

As the area of robotics moves from applications in industrial environments, to providing services in new scenarios, several key issues need to be addressed. These include finding technical solutions for the wide range of functionalities required, at affordable cost, making the robots more reliable and acceptable to the general community, and also designing interfaces to allow the users to interact with the new robots. As this happens, and the robots become more intelligent, it is necessary to make sure that other socio-economic aspects are adequately addressed. In this regard, we argue that the two primary considerations are standards and ethics. Standards are needed to formalise and define the arrangements from technical and organisational aspects; and ethics are needed to ensure that the new “cognitive” systems have a proper role and standing in society. It is clear to the authors that the two are closely related and need to be viewed in conjunction with each other.

Initially, the need is for service robotics to have good standards which allow safe, and acceptable, adoption into society, and as the sophistication of the technology grows, and robot autonomy improves, the ethical side of the robots becomes more important. The primary driver for robot

standards is safety and generic acceptability, whereas that for robot ethics is an appropriate level of “dignity” for both the user and the robot. Dignity for the robot may be premature at the moment because the systems are not smart, or cognitive enough to warrant it, but the situation is changing rapidly and we believe the time is appropriate to at least start the debate. Currently robots do not have the cognitive awareness, sophistication or capacity to perceive their “own worth” and realise they are being exploited in the various applications. It is the authors’ opinion that it is necessary to define the core features that need to be included in establishing an appropriate level of dignity for robots. At the moment, robots are viewed as electro-mechanical machines or “mere gadgets” and they do not have any worth regarding values related to dignity. This perception is expected to evolve as robots become more sophisticated in their intelligence and reliability, and as they become more accepted in society. In view of this, the paper will not explore these ethical issues here, but will initiate an investigation into their acceptability to perform various everyday tasks.

In terms of where standards and ethics meet, this is also a matter of debate and viewpoints of different people. In both these aspects the public acceptance of robots and robotics in everyday life is essential and this forms the focus of the current paper.

It is important to remember that, no matter how careful we are in producing and adopting good safety standards, accidents can always occur. The aim of the standardisation and ethical activities is to prevent such problems as much as possible and to provide good guidelines that are acceptable to citizens and society. To illustrate the problem, in 1981, Kenji Urada, a 37-year-old Japanese factory worker, was pushed into a grinding machine by a

robot. This gruesome industrial accident would not have happened if the robot's behaviour was governed by the original Three Laws of Robotics as drawn up by Isaac Asimov, a science-fiction writer (later a Zeroth law was added focussing on humanity). The laws appeared in "I, Robot", a book published in 1950 that inspired a recent Hollywood film. But decades later the laws, designed to prevent robots from harming people either through action or inaction, remain only in the realm of fiction.

Indeed, despite the introduction of improved safety mechanisms, robots have claimed many more victims since 1981. Over the years people have been crushed, hit on the head, welded and even had molten aluminium poured over them by robots. Last year there were 77 robot-related accidents in Britain alone, according to the Health and Safety Executive.

2. Robot Standards

Traditional robots have been designed for industrial use and the safety measures have been based on separating the robot and the human while the robot is operating. As applications for robots increase into new sectors, and as traditional robots are used in new ways, the need for closer robot-human interaction and collaboration has grown. Some of the newly needed safety requirements for collaborative human-robot operation for "robots in industrial environments" are covered in the recently accepted ISO 10218-1 standard. This states that the robot must provide a visual indication when it is in "collaborative operation" and comply with one or more of the following:

1. The robot must STOP when a human is in the collaborative workspace.
2. In hand-guiding mode, the robot shall operate at a reduced speed determined by a risk assessment, but <250mm/sec.
3. An appropriate separation distance (ISO 13855) from the operator shall be maintained.
4. The robot shall be designed to have a maximum dynamic or static power of 80W or 150W respectively.
5. The robot's maximum power and force shall be limited to the above mentioned by a control system.

In service robotics, the requirement for close robot-human interaction is significant, and so it is useful to categorise the interaction and collaboration, based on the spatial distance between the robot and

human, into four main categories, namely, "Far away", "Close", "Touching" and "Invasive" where the distances are expressed heuristically as large, small, zero and negative. The actual permissible distances will depend on a full risk assessment of specific scenarios and applications.

The new ISO 10218-1 standard covers the scenarios where human-robot collaboration is "far away". "Far away" to "close" collaborations are also covered, essentially by forcing the robot to reduce its power and force. The operation of the service robots in "close", "touching" and "invasive" scenarios are not covered adequately in that the robot may be unable to perform its required function when the human is "too close". Hence new standards focusing on these three areas for (service) robots to perform their designed function are needed. Such activities have been proposed in new work items under ISO TC184 (Automation systems and integration).

3. Robot Ethics

In recent years, as robots become more sophisticated and their autonomy levels increase, people are beginning to raise ethical issues. Many of these stem from science fiction viewpoints, and the fear of "machines taking over the planet", and attempts to control the adoption of the technology to protect human skills and jobs. Others attempt to regulate the operation of robots in various areas such as humanoid robots, war machines, sex devices, etc.

To date the problems have been of an academic nature because real robots are still in their infancy and have, in the main, been limited to industrial environments or hazardous areas where humans cannot be employed and so there are no real human-robot interactions to worry about. However, as the area of "service robotics" becomes closer to reality, it becomes more urgent to debate the issues and how best to integrate the technology into everyday society.

Although there are many application sectors where close human-robot interaction will be needed, we focus here on the ethics for healthcare robots because the societal need to address the ageing problem is high, and the human-robot interface is as important as it can be for designing robots. The ethics for this rely on the ability of the robot to perform the task needed, and the acceptability to humans of using robots for such tasks.

4. Public acceptability of robots for personal care

With reference to the care sector, very few studies have focused on robots in healthcare, except for the use of robots in surgery. Nevertheless, there have been some studies focusing on the use of robots in caring, e.g. robot-assisted activity/interactive toys in dementia care [1], [2] and robot-therapy in stroke rehabilitation [3], [4], though ethical discussion is sparse concerning issues such as autonomy, independence, integrity and dignity. A systematic review [5] of the widely practised standards and ethics in studies of technology-based homecare for elderly people also showed that these issues, i.e. practice standards and ethics, were not well reported.

Studies concerning people's opinions of technology in care differ quite significantly. Studies [6], [7] of elderly people have shown that they are, in general, positive to assistive technology in healthcare and especially in the home if this allows them to stay in their own home doing their usual activities. Studies of caregivers show both optimistic and pessimistic opinions/experiences of technology. For example, a study [8] of caregivers' reflections about using information technology in elderly care showed categories as genuineness and superficiality, freedom and captivity, and dignity and unworthiness. A defensive attitude was common and technology was viewed as something that promoted both human and inhuman care. In another study [9] technology was described as; machinery and equipment, changes to skills, increasing knowledge, gaining control of clinical practice, clinical resources must meet the needs of technology, the need to include the patients' experience and clinical presentation, and as alteration to the free will of nurses. Caregivers' traditional view of place and presence in nursing needs to be considered when new technologies are introduced [10] and might be one explanation to these sometimes diverse opinions of technology.

To summarise, little research has so far been done in the field of robotics in the care and nursing section. The concern not only lies in the technology itself but also in how, where and under what circumstances it will be used, which emphasises the need of a multidisciplinary approach to this new field. Nevertheless, of utmost importance is the free will of the individual to choose their care alternatives based upon their personal situation, needs and preferences. As pointed out by Stanberry [11] one of several

dangerous consequences of telemedicine/technology is the loss of personal choice in how we receive different services in the care sector. A good starting point is therefore to study peoples' opinions concerning the use of robots in the home care sector.

Research in healthcare robotics has been carried out to assess the acceptability of having robots to assist with a variety of personal care tasks, and the ethical issues that these aspects raise. A primary consideration is that the general public's confidence level in robots must be identified and monitored as the technology grows and is integrated in various sectors of society. To initiate this work a questionnaire has been produced and used to gather data from people from various sectors. The questions have been built on those formulated within the EC Climbing and walking robots network (CLAWAR). The questionnaire has been used in conducting a public survey to determine the acceptability of robots for performing these personal care tasks. The details of the questionnaire and the initial results of the survey are presented next.

5. Initial results from survey

Thirty-one persons participated in the initial study and the mean age was 47.8 years (SD 12.3) (22 women, mean age 48.2 years [SD 10.9] and 8 men, mean age 46.6 years [16.2 SD]). The participants' job titles were; 19 lecturers (working at departments for caring sciences, sociology or technology), 1 medical doctor, 1 editor, 1 professor, 2 students, 2 researchers, 4 participants with administrative function at a university and 1 reader. Twenty-one participants were from Sweden, 8 from UK, 1 from Spain and 1 from Italy.

A summary of the results is presented in Table 1. Response alternatives were: 1) Strongly disagree 2) Partially disagree 3) Don't know 4) Partially agree 5) Strongly agree. Statistically significant differences between men and women were analysed using the Mann-Whitney U-test.

Responses with P-value less than 0.05 are statistically significant. Using this metric, two aspects are clear from the present survey, namely:

- People are ready to accept robots into their homes, men showing a statistically significant higher median value compared with women for this statement.
- The perception that the use of robots for personal care has strong ethical issues among women. Women rated a statistically significant

higher median value for this statement compared to men.

Table 1: Acceptance of personal care robots, median values

	All (n=30-31)	Men (n = 8)	Women (n=21-22)	P-value
Would you be prepared to have a robot in your home	4.0	4.5	4.0	0.046
Would you trust a robot to - cut the grass?	5.0	5.0	4.0	0.412
- vacuum clean your house?	4.0	4.5	4.0	0.314
- exercise your pet?	3.0	4.5	3.0	0.085
- prepare you a meal?	3.0	2.5	3.0	0.755
- help you put on your shoes?	4.0	4.5	4.0	0.287
- style your hair?	2.0	2.0	2.5	0.371
- measure your blood pressure and take your pulse?	4.0	5.0	4.0	0.140
- put drops in your eyes?	3.0	2.5	3.0	0.755
- give you an injection?	2.0	3.0	2.5	0.827
- cut your toe and finger nails?	2.0	2.0	2.0	0.808
- remove your teeth?	1.0	1.5	1.5	0.980
- support to move around your home & reduce falls?	4.0	4.5	4.0	0.322
- be a support for you when walking outside?	4.0	4.0	4.0	0.599
Happy to have operation performed by a robot?	4.0	4.0	2.5	0.367
Prepared to have a robot as your home help, etc?	3.0	4.0	2.5	0.309
Ethical problems when robots are used in personal care?	4.0	2.0	4.0	0.014
Can a robot increase the independence for people?	4.0	4.0	4.0	0.795

Although the survey is continuing with more detailed questionnaires as well as more respondents from a wider range of backgrounds, there are some general statements that can be made from the initial data, namely:

- Men and women both find the idea acceptable of using robots to perform routine, tedious tasks.
- The idea of robots performing tasks that require some artistic decisions are not yet acceptable to most people.
- Personal healthcare tasks that are not too invasive are acceptable.
- More invasive personal care tasks are not yet acceptable.

The number of completed questionnaires is too low to make some deductions on gender aspects in the viewpoints. The work is continuing and further results will be published as they become available.

6. Conclusions

The paper presents issues related to standards and ethics for adopting robotic technologies. An initial questionnaire has been prepared and used to gather data on several aspects on the acceptability of robots to perform various tasks. These results indicate that robots are becoming acceptable and the time may be right to develop prototype solutions for testing this acceptability further. A more comprehensive questionnaire should be finalised and used to gather data from the general public in a more comprehensive manner. The surveys should be repeated regularly to monitor the changing perception which correlates closely with the quality of the robots available to be used to perform personal service tasks.

7. Acknowledgements

The authors acknowledge the EC funding for the CLAWAR TN and to the CLAWAR Members who assisted in the preparation of the questionnaire. Thanks are due especially to Phil Skelton who initiated this activity within the CLAWAR membership.

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“Our Ageing Society – The Challenges of Appropriate Supportive Technology”

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The seminar titled *Our Ageing Society – The challenges of appropriate supportive technology* was held in the Institution of Engineering Technology (IET), London, UK, on 31st January 2007. The programme was organised through the IET robotics network and was sponsored by the Strategic Promotion of Ageing Research Capacity womb. Currently the world population aged over 65 is 7% and in 40 years, it will increase to 20%. The clear message is to improve attitudes towards the elderly in physical and mental fitness starting with greater activity from health organisations worldwide.

Professor, Roger Orpwood, Director of the Bath Institute for Medical Engineering discussed “User-led design to support older people” which is defined at the user interface. Often a considerable amount of design, thought and care is required for the disabled/older people. Successful product design and developments are achieved by face to face questioning and by interpreting behaviours. Concluding, Roger noted that “work in the field is showing benefits that can arise from careful, sensitive applications of technology, but it has to be accepted that technology is never going to replace the warmth and understanding of human care”.

Leslie Sopp, Head of Research at Age Concern Research Services discussed “The issues and opportunities around the increasing older population”. This was defined as 50+, where the 3 major concerns are: Health and activeness; crime levels and the health service; the care role, and concerns over family life. Adaptations to existing aids are most economic & practical. Smart homes are all theoretically useful, but there are technological concerns for safety, especially when mobility is incorporated into the assistive devices.

The afternoon session was a series of panel sessions to discuss whether technology will keep us in our own homes for longer. Sessions were run by *Dr Arlene Astell* from St Andrews University, *Oliver Wells* from Imperial college and *Kevin Doughty* from Sunrise Medical. Following on from this we all participated in a Delphi type road mapping session organised by *Catherine Fieschi*, DEMOS UK. The findings are to be published and further information can be found at www.demos.co.uk.

Finally, *Kathryn Brown*, from the DTI, explained “Mechanisms for encouraging innovation”. The DTI’s Office of Science and Innovation is aimed at improving the UK’s technological innovation performance and to accelerate business exploitation of science and technology. This includes collaborative R&D in key technology areas, funded technology & platform programmes & knowledge transfer networks. A health care white paper was published in 2005. Further information on the white paper and the technology programme can be found at: www.dh.gov.uk and

www.dti.gov.uk/innovation/technologystrategy/index.html

Author's personal comments: I had the distinct impression from those present that robotics will not solve the problem of providing aid for the elderly, but it will help in a limited way. Opinion at the seminar was that very basic devices or modifications to existing systems only are required at this stage.

In my opinion, the CLAWAR Association should perhaps address this very worthwhile and necessary cause and demonstrate that robotic assistance can be a valuable tool, after all, ageing will affect most of us – eventually, and if we are lucky enough!

Introduction to RoboCup

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History

RoboCup (www.robocup.org) is an international research and education initiative that started in 1992. Its goal is to foster artificial intelligence and robotics research by providing a standard problem, *robotic soccer*, where a wide range of technologies can be examined and integrated. In 1997, the first official conference and games were held in Nagoya, where three leagues of robot soccer games, namely; small sized wheeled robot, middle size wheeled robot and the simulation league were introduced. The four legged robot league and the humanoid league were added in 1998 and 2002 respectively.

RoboCup serves as a task for a team of multiple fast-moving robots with a dynamically changing environment. It also offers a software platform for research on the software aspects of the task involved. The ultimate goal of RoboCup is to develop a team of fully autonomous humanoid robots that can win against the human world champion team in soccer by the year 2050.

RoboCup also initiated RoboCup Rescue league to specifically promote research in socially significant issues such as search and rescue in large scale disaster, which involves very large numbers of heterogeneous agents in a hostile environment. The RoboCup Rescue league aims to promote research and development in this significant domain by involving multi-agent team work coordination, physical robotic agents for search and rescue, information infrastructures and decision support, into a comprehensive system in future.

Robocup 2007: a competition zone

In order to promote awareness and interest in youngsters, a RoboCup Junior competition is held in parallel with RoboCup games. RoboCup Junior offers several challenges (soccer, dance and rescue), each emphasizing both cooperative and competitive aspects in robotics. For young students, RoboCup provides a new arena for them to develop technical abilities through hands-on experience with electronics, hardware and software, and a highly motivating opportunity to learn about teamwork while sharing technology with friends.

Robocup 2007: a rescue robot

The RoboCup@Home competition debuted in 2006. RoboCup@Home, as a new standard problem, focuses on real-world applications and human-machine interaction with autonomous robots. The participants are given an environment that involves a kitchen, a living room, and possibly more, and then they demonstrate their robots' abilities in that environment. The first demonstration was held in at Bremen, Germany in the year 2006.

RoboCup 2007 in Atlanta, USA

The most recent RoboCup competition was held in Atlanta, USA from 1-10 July, 2007. It attracted 321 teams and 1600 participants from 39 countries around the world.

RoboCup 2008 in Suzhou, China

RoboCup 2008 will be held in Suzhou, China, from 14-20 July, 2008. Year 2008 is a significant year for China as it is also hosting the Olympic games. It can be expected that RoboCup2008 will be another successful event.

Robocup 2007: a humanoid robot

Omni-directional Mobile Robots as Educational Platforms

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1. Introduction

Mobile robots are already widely used for surveillance, inspection and transportation tasks. One of the main requirements of an autonomous mobile robot is its ability to move through the operational space, avoiding obstacles and finding its way to the next desired location. In order to move in tight areas and to avoid obstacles, mobile robots should have good mobility and manoeuvrability. These capabilities mainly depend on the design of the wheels and their configuration.

This paper introduces an omni-directional mobile robot for educational purposes. The robot has full omni-directional motion capabilities, thanks to its special Mecanum wheels. The results presented here are the result of research conducted at the Robotics Laboratory of the Mechanical Engineering Faculty, "Gh. Asachi" Technical University of Iasi, Romania.

2. Omni-directional Mobility

The term 'omni-directional' is used to describe the ability of a system to move instantaneously in any direction from any configuration. Robotic vehicles are often designed for planar motion; they operate on a warehouse floor, road, surface of a lake, table top, etc. In such two dimensional spaces, a body can have three degrees of freedom. It is capable of translating in both linear directions as well as rotating about its centre of gravity. Most conventional wheeled vehicles however do not have the capability to control all these possible degrees of freedom independently.

Conventional wheels are not capable of moving in a direction parallel to their axis. This so called non-holonomic constraint of a standard car-like wheeled design prevents the vehicles using skid-steering, from moving perpendicular to its drive direction. While it can generally reach every location and orientation in a 2D space, it can require complicated manoeuvres and complex path planning to do so (Fig. 1). This is the case for both human operated and robotic car-like vehicles.

When a wheeled vehicle has no holonomic constraints, it can travel in any direction from any

orientation. This capability is referred to as omni-directional mobility.

Omni-directional vehicles clearly have advantages over conventional (non-holonomic) platforms, governed by car-like Ackerman steering or differential drive systems, when moving in tight areas [1]. They can crab sideways, turn on the spot, and follow complex trajectories. These robots are capable of easily performing complex manoeuvring tasks in environments with static and dynamic obstacles and narrow aisles.

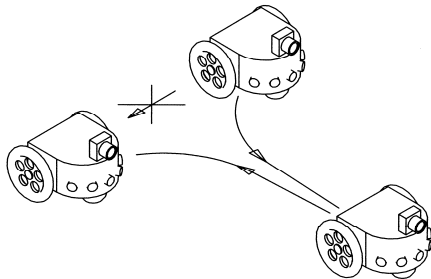


Fig. 1: Lateral parking of a differential car-like wheel drive mobile robot

Omni-directional vehicles are divided into two categories depending on the type of wheel arrangement they use for mobility: conventional wheel designs or special wheel design.

3. Wheel Designs

3.1 Conventional wheel designs

Conventional wheeled designs used for mobile robots with omni-directional capabilities can be further broken into two types, namely castor wheels and steering wheels. They have larger load capacities and a higher tolerance for ground irregularities compared to the special wheel configurations. However, due to their non-holonomic nature, they are not truly omni-directional wheels. Hence, these designs are not truly omni-directional because when a move with a non-continuous curve is encountered there is a finite amount of time needed before the steering motors can re-orient the wheels to match the projected curve [5]. Most platforms that contain conventional wheels and approximate omni-directional mobility incorporate at least two independently steered and independently driven wheels [1]. Active castor wheels or conventionally steered wheels can be used to achieve this near omni-directional mobility.

3.2 Special wheel designs

Special wheeled designs are based on a concept that activates traction in one direction and allows passive motion in another, thus allowing greater

flexibility in congested environments [12]. These designs can include the universal wheel, the Mecanum (Swedish) wheel, and the ball wheel mechanism. The universal wheel provides a combination of constrained and unconstrained motions during turning. The mechanism consists of small rollers located around the outer diameter of the wheel to allow for normal wheel rotation, yet be free to roll in the direction parallel to the wheels axis. The wheel is capable of this action because the rollers are mounted perpendicular to the axis of rotation of the wheel. When two or more of these wheels are mounted on a vehicle platform, their combined constrained and unconstrained motion allows for omni-directional mobility.

The Mecanum (Swedish) wheel is similar to the universal wheel in design except that its rollers are mounted on angles as shown in Fig. 2. This configuration transmits a portion of the force in the rotational direction of the wheel to a force normal to the direction of the wheel. The platform configuration consists of four wheels located similarly to that of an automobile. The forces due to the direction and speed of each of the four wheels can be summed into a total force vector, which allows for vehicle translation in any direction.

Another special wheel design is the ball wheel mechanism. It uses an active ring driven by a motor and gearbox to transmit power through rollers and via friction to a ball that is capable of rotation in any direction instantaneously. Each of these mentioned designs with special wheels achieve excellent manoeuvrability, but are limited to hard even surfaces due to the small roller diameters.

4. Mecanum wheel design

One of the more common omni-directional wheel designs is that of the Mecanum wheel, invented in 1973 by Bengt Ikon, an engineer with the Swedish company Mecanum AB [8]. The wheel itself consists of a hub carrying a number of free moving rollers angled at 45° about the hub's circumference (see Fig. 2).

these wheels provides omni-directional movement for a vehicle without needing a conventional steering system. In our case, we have chosen a square configuration, in order to simplify the mathematical model and, obviously, the motion control of it (Fig. 4). Our robot is a 450 [mm] long, 382 [mm] wide and 220 [mm] high platform.

Fig. 2: Mecanum wheel

The angle between the rollers' axis and the central wheel axis could have any value but in the case of conventional Swedish wheels it is 45° . The angled peripheral rollers translate a portion of the force in the rotational direction of the wheel to a force normal to the wheel direction. Depending on each individual wheel direction and speed, the resulting combination of all these forces produce a total force vector in any desired direction thus allowing the platform to move freely in the direction of the resulting force vector, without changing the wheels themselves.

The rollers are neither actuated nor sensed. The key advantage of this design is that, although the only wheel rotation is powered along the main axis, the wheel can kinematically move with very little friction along many possible trajectories, not just forward and backward [12].

A Swedish omni-directional wheel has 3 DOFs composed of wheel rotation, roller rotation, and rotational slip about the vertical axis passing through the point of contact (see Fig. 3).

Fig. 3: DOFs in a Mecanum wheel [11]

5. Robot design

5.1 Mechanical design

Typical Mecanum-wheel based vehicles have a square or rectangular configuration, with two wheels on each side of the chassis. Using four of

(a)

(b)

Fig. 4: Omnidirectional robot: (a) CAD design and photo of the 1st prototype; (b) the 2nd prototype

Each wheel is actuated by its own DC geared MAXON motor. Because the omni-directional capability of the robot depends on each wheel resting firmly on the ground, some are equipped with suspension systems. Even if these designs are for indoor applications (this means they are moving on flat surfaces), having four wheels, they need a suspension system just in case of small undulations that could exist on the ground. In our case, a passive suspension system with two spatial four-bar mechanisms is used, in order to easily adapt the system to the ground (Fig. 5).

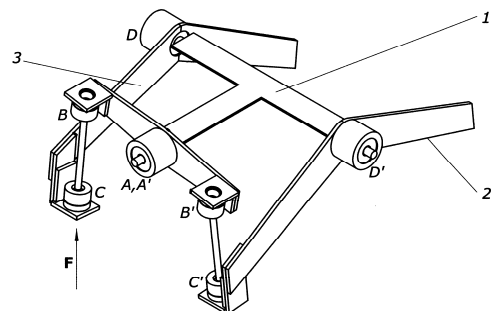


Fig. 5: Suspension mechanism

At this time, three solutions for motion control are implemented in the microcontroller: remote control mode; line-follower mode; and autonomous mode, thanks to an ultrasonic pair of sensors and bumper bars.

Because a single pair of ultrasonic sensors is used, the module is always swinging using a servo and a supplementary gear transmission, mounted on the top of the robot. Even if the servo has an angular stroke of 180° , thanks to the gear transmission, the sensor is able to scan an angle of 360° . To avoid obstacle collisions when the robot is going backward for an obstacle avoiding, and also when it runs into an obstacle under a small angle, two supplementary pairs of switches have been added (one pair in the front and one in the back).

5.2 Electronics

As we have mentioned before, the robot can be remote controlled, using a command system (Fig. 6), or it can follow a line or to be autonomous, using an ultrasonic sensor for obstacle avoidance.

Fig. 6: Command system

In order to receive commands from the system presented in Fig. 6, or to detect obstacles and to drive the motors, an electronics board based on a PIC16F876 microcontroller, and placed on the robot, is used (Fig. 7).

7. Conclusion and future work

Omni-directional vehicles have great advantages over conventional (non-holonomic) platforms, with car-like Ackerman steering or differential drive system, for moving in tight areas. They can crab sideways, turn on the spot, and follow complex trajectories. These robots are capable of easily performing tasks in environments with static and dynamic obstacles and narrow aisles. Such environments are commonly found in factory workshops, offices, warehouses, hospitals, etc. Flexible material handling and movement, with

real-time control, has become an integral part of modern manufacturing.

This paper introduced an omni-directional mobile robot with Mecanum wheels for educational purposes. The robot has full omni-directional motion capabilities, thanks to its special Mecanum wheels. A real size omni-directional vehicle will be built during the next years (Fig. 8).

Fig. 7: Electronic board

Fig. 8: Artistic view of the future vehicle

Acknowledgment

The authors wish to thank to the Romanian National University Research Council for their financial support (Grant ID-622). Thanks to this grant, a real size vehicle is proposed to be built (see Fig. 8).

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The purpose of the 11th 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.

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