Editorial

Yong Yue*, Carsten Maple and Dayou Li

Department of Computer Science and Technology,
University of Bedfordshire,
Park Square, Luton LU1 3JU, UK
Email: yong.yue@beds.ac.uk
Email: carsten.maple@beds.ac.uk
Email: dayou.li@beds.ac.uk
*Corresponding author

Biographical notes: Yong Yue is Professor of Computing Technology at the University of Bedfordshire, UK. He holds a BSc in Mechanical Engineering from Northeastern University, China, and a PhD from Heriot-Watt University, UK. He is a chartered engineer and a member of the Institution of Mechanical Engineers, UK. His research interests include CAD/CAM, geometric modelling, computer graphics, virtual reality and robotics, and he has over 100 research publications.

Carsten Maple is a Professor of Applicable Computing at the University of Bedfordshire, UK. He holds a BSc in Mathematics from the University of Leicester, where he also obtained a PhD in Numerical Analysis. He is a Fellow of the British Computer Society and is an elected member of the committee of the Council for Professors and Heads of Computing in the UK. His research interests include intelligent control systems, optimisation strategies, distributed systems and information security. He has over 100 publications in refereed books, journals and conferences.

Dayou Li received his BEng and MSc degrees in Railway Transportation and Control from Beijing Jiaotong University (China) in 1982 and 1985, respectively. In 1999, he obtained his PhD degree in Fuzzy Backward Reasoning Control from Cardiff University (UK). His main research areas include artificial intelligence and robotics.

Planning and control are fundamental aspects of robotics and research in the area has transformed the efficiency and effectiveness of robots. Modern robotic systems have come a long way since the early days of Unimate and Shakey the Robot in the 1950s and 1960s. These advances arguably owe more to developments in planning and control than in engineering. Current robots undertake and successfully complete complex mechanical feats such as climbing between two walls, running and traversing rough terrain.

Most robots are either controlled remotely by an expert, such as devices for robotic surgery or hazardous exploration, or programmed to execute a specific task. An example of the former is OmniTread, a serpentine robot designed and developed at the University of Michigan with a purpose of traversing extremely difficult terrain, such as the rubble of a collapsed building. It can also drive over sand and rock sand, pass through small holes and climb over tall obstacles. It is for those that are programmable that the importance of planning and control comes to the fore. For such robots, when a different task is required, the robot must be reprogrammed. This process can often be time-consuming and expensive due to the requirement of task-specific algorithms that require significant validation effort to allow these machines to be autonomous.

There has been a great deal of activity in the field of planning and control for robots over the last 30 years. During this time there has been a proliferation of specialist journals, major textbooks at all levels and leading monographs. The work undertaken has developed theory and applications in the areas of sensing, processing and action. The papers presented in the special issue include advances in each of these areas.

This issue commences with a paper describing research undertaken at the National University of Singapore. There has been some recent activity in the area of swarm robotics, which concerns the control and coordination of large numbers of simple physical robots. The paper considers the issue of robustness in swarm systems when an individual swarm unit fails. The work considers swarms which develop imperfections in units or are deployed in hazardous situations in which units have a certain probability of failure. The work investigates the balance increased robustness afforded by a larger swarm and the greater interference resulting from large swarm sizes. This interference can hinder the performance of the swarm as a whole. The paper provides new ideas on the optimisation of swarm size.

The second paper of the issue again uses ideas from swarm algorithms for a different application. In this paper, ‘Particle swarm optimisation of a discontinuous control for a wheeled mobile robot with two trailers’, ideas are developed to stabilise a nonholonomic mobile robot with two trailers. The use of the swarm optimisation technique is to tune the controller parameters. In this work by researchers at the Sultan Qaboos University in Muscat, the effectiveness of the new approach is demonstrated by means of simulations.

The third paper utilises a different idea from the field of artificial intelligence, that of genetic algorithms. Genetic algorithms are used in the solution for dead-end problems, a common issue for mobile robots negotiating complex terrains featuring multiple obstacles. Indeed, for a number of application areas, dead-end problems arise not only due to the robot having taken a sub-optimal path, but as a matter of course as the whole terrain needs to be explored. Typical applications in which such explorations arise are hazardous situations such as bomb disposal or rescue work. The paper presents an approach which enables a robot to escape dead-end areas. The work comprises two parts: a dead-end detection mechanism and a GA-based online training mechanism. When the robot realises that it is stuck in a dead-end area, it will operate the online training to produce a new best chromosome that will enable the robot to escape from the area.

The area of nanotechnology is one of the hottest and most fertile areas of research currently. The concept of nanotechnology is now past its 50th year; Richard Feynman gave his seminal talk 'There's Plenty of Room at the Bottom', in a meeting of American Physical Society at Caltech on 29 December 1959, in which he described a process by which the ability to manipulate individual atoms and molecules might be developed. The term nanotechnology itself was only defined some 15 years later by Professor Norio Taniguchi and only in the 1980s was the definition explored in more detail by K. Eric Drexler, through talks, papers and the book *Engines of Creation: The Coming Era of Nanotechnology* in 1986. Since this time there has been significant growth in interest in the area and the fourth paper in this issue considers current developments and challenges in robotic nanoassembly. The work is a collaboration across four institutions in China and the UK and discusses scanning probe-based 2D nanomanipulation, gripper-based 3D nanohandling, object-oriented nanoassembly and hybrid nanoassembly techniques. These can be described as being some of the most key topics of interest in the field.

The fifth paper describes work undertaken collaboratively between the Madras campus of the Indian Institute of Technology and the Graduate University for Advanced Studies in Tokyo. The paper investigates a hybrid method for the coordination control of wheeled mobile robots. A novel modelling and hybrid formation control approach for the autonomous navigation for group of mobile robots in a specified formation is presented. The hybrid approach comprises a supervisor level to determine the high-level aspects such as formation and inter-robot communication, and a lower level which deals with the dynamic control of the robots when navigating in the environment. Experimental investigations are presented by using two commercially available robot research platforms.

In the next paper, a new method for modelling of adaptive control laws for controlling robot manipulators is presented. The author builds upon previous work based on Lyapunov theory, and proposes five new adaptive control laws to guarantee stability of an uncertain system. These laws are developed using various changes in variables to ensure stability. The theories are applied to a two-link robotic manipulator to demonstrate through numerical simulation the power of the ideas.

The seventh paper presents work from two universities in Japan. This paper addresses an important control problem for an underactuated system in terms of control theory and industrial application. The paper proposes an idea that an original two-link system can be transformed into the input affine systems, which allows the controller for each sub-system to be designed independently, considering the influence of the control input designed for the other sub-system as an input disturbance. In designing the controllers for the sub-systems, a sliding-mode type partial linearisation method which is robust for input disturbance is adopted. The effectiveness of the proposed method is demonstrated by simulation experiments.

Collaborative work between South Korea and China is presented in the eighth paper of this issue, 'Design of Active Front Steering (AFS) system with QFT control'. The paper describes work in which a QFT control strategy is used for active front wheel steering by incorporating feedback from a yaw rate sensor. The application of the method is explored using a multi degree-of-freedom nonlinear vehicle model that is co-simulated with MATLAB Simulink and ADAMS/CAR. The performance of the control system is considered under various emergency manoeuvres and road conditions. The results are encouraging and demonstrate the handling qualities and stability characteristics of the method presented.

The kinematic and dynamic behaviours of a robot manipulator on an elastic catenary cable have been investigated in the next paper, 'Analysis of a dual-arm mobile robot dynamics and balance compensation', by researchers at Shanghai University. Dynamic equations of a robot and cable are derived based on the Newton-Euler principle and Hamilton principle, respectively. The paper investigates the recursive formulations describing the nonlinear and coupling dynamics relationship between the robot and the cable. A dynamic compensation technique with complementary control strategy is developed and implemented to adjust the posture of the robot and limit vibration. The effectiveness of the dynamic compensation is demonstrated through simulation.

The tenth paper features work undertaken at the University of Essex and concerns visual-guided walking robots. This paper presents a novel landmark modelling approach for environment sensing through visual perception. The approach integrates image descriptors for defined landmarks (natural and artificial) and novelty features being dynamically detected. The ideas presented in the paper are implemented in a quadruped walking robot with a single camera. Experimental results are presented to demonstrate the feasibility and performance of the approach.

The next paper considers a space robot with a manipulator arm mounted on a satellite body. This work proposes control methods for stabilising both the main body angle of a space robot and the joint angles of a manipulator independently and simultaneously. The methods presented are based first on a time-varying feedback controller, and then on a time-invariant feedback controller. Interestingly, the former controller is theoretically successful but has practical limitations and the latter controller has theoretical incompleteness but is practically more useful.

The penultimate paper in the issue comes from the University of Evry in France. The paper concerns flying robots and discusses methods to generate a desired flight path to be followed by an aerial robot. The work considers flight paths with continuous curvature and torsion so as to ensure smooth motion. The work classifies curves into three different areas. Curves under consideration include those with constant curvature and torsion, a linear variation versus the curvilinear abscissa then a quadratic variation, and two trim helices of different curvature and torsion.

The issue closes with work from Northeastern University in China. The paper concerns an intelligent bionic leg and its modelling and control. The leg is controlled by magneto-rheological (MR) damper and can be described as an advanced prosthetic. The kinematics dynamics models have been developed in detail and the modified sigmoid model of the MR damper is proposed. The aim of the paper is to investigate if the intelligent bionic leg controlled by an MR damper can track human normal gait well. This paper shows the advantages of the use of the magneto-rheological damper through simulation.

It is the belief of the editors that the work presented in the issue describes and analyses key developments in the field of planning and control in robotics. The papers represent advances in vast array of avenues in the field, from control to planning, from static to dynamic robots, from wheeled to airborne. It is hoped that these papers be a platform for further work in the area and stimulate interest for future developments.

Overall we feel that these papers cover quite a spectrum of what is a novel yet highly important research field. Whilst they can, by no means, be regarded as describing a well-researched field in its entirety, conversely they give a clear indication of the present state of play and point to exciting opportunities for future research programmes and investigations in the years ahead.

Finally, we would like to thank both the contributors for their submission and revision, and the anonymous reviewers for their constructive comments and recommendations to improve the papers. Our sincere thanks go to Editor-in-Chief, Professor Quan Min Zhu, for his support to this special issue.