9th IEEE International Conference on Mechatronics and Machine Vision in Practice, 2002

Chiang Mai, Thailand, 10-12 September 2002

Programme and Abstracts

Supported by:

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We would like to thank the following, all from Chiang Mai University, for their assistance on the local organising committee:

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Welcome

Once again we would like to welcome you to the annual conference on Mechatronics and Machine Vision. This is the 9th in the series and we hope that it will be as successful and enjoyable as the previous eight.

This year we have the pleasure of organising the conference in Thailand. This gives that country and opportunity to present to a world-wide audience its advances in technology, and we are very pleased that many Thai researchers are presenting papers. The papers presented at this conference have been through a rigorous refereeing process; more than 25% of the original submissions were not accepted! Around 40 of the papers presented here, after further refereeing, have also been published as a book, which will be available at the conference.

We have papers from many countries in the ASEAN region, as well as places like Kazakhstan and Saudi Arabia, along with many countries in Europe and N America, where we have not had contributors before. Of course, many of our 'old friends' from previous conferences will be here and we extend a warm welcome to them too. However, it is good to notice that the conference has outgrown it's Asia-Pacific roots and is now a truely international event.

As in previous conferences, the title belies a wide variety of applications areas and so it has been the usual hard struggle to get the papers into some sort of order so that as-near meaningful session titles can be attempted. If you find a paper out of place, then please try and suggest where it might have gone!!

One recurring characteristic of these conferences is the non-technical aspects of the programme, especially the food and drink! This time it's no different, and Chiang Mai has put on a good deal of entertainment for us - 4 nights of receptions, dinners and banquets for 3 days technical programme. We must thank the local organising committee for this.

Whilst in Chiang Mai we hope that you can stay a few extra days and explore the region; it is definitely one of the most fascinating areas in Thailand.

Robin Bradbeer
John Billingsley

Programme

Monday 9th September

6:30-9:00pm
Welcome Reception and Pre-registration
Chiang-Mai Orchid Hotel

Tuesday 10th September

9:30-10:00am
Room 1
Opening Ceremony
Session Chairs: John Billingsley, Theeraphong Wongratanaphisan
President, Chiang Mai University, Thailand
Mayor, Chiang Mai, Thailand

10:00am-10:30am
Room I
Plenary Session 1
Session Chair: Theeraphong Wongratanaphisan
Mechatronics and engineering research in Thailand
Dr. Djitt Laowattana
Institute of Field Robotics, King Mongkut's University of Technology,
Thonburi, Thailand

10:30am-10.50 am
Morning Tea/Coffee

10.50am-12:30pm
Room 2
TuA1: Industrial Applications I

Session Chair: P Sooraska

10.50am: Active control of internal turning operations using a boring bar; Linus Pettersson; Sweden (Abs 01)

11.15am: Fabric defect classification using wavelet frames and minimum classification error based neural network; Grantham Pang; Hong Kong (Abs 02)

11.40am: Multiple robot control using force/torque and vision sensors; Devendra P. Garg; USA (Abs 03)

12.05pm: Fully automated raw foundry brake disc dimensional characterisation and inspection through several computer vision systems; Pedro Martín Lerones; Spain (Abs 04)

10.50am-12:30pm
Room 3
TuA2: Agriculture and Food I

Session Chair: Bing Luk

10.50am: A prototype mechatronic system for inspection of date fruits; Abdulrahman A. Al-janobi; Saudi Arabia (Abs 05)

11.15am: Autonomous agricultural robot; Mark Phythian; Australia (Abs 06)

11.40am: Visual counting of macadamia nuts; John Billingsley; Australia (Abs 07)

12.05pm: Machine vision application to grading of white pepper berries; Mani Maran Ratnam; Malaysia (Abs 08)

12:30pm-1.45pm
Lunch
Thai buffet

1.45pm-3.00pm
Room 2
TuP1: Manufacturing Mechatronics Design I

Session Chair: John Billingsley

1.45pm: The resolving of tasks of dynamics for control of the single-planimetric multimobile manipulator; Korgan Sholanov; Kazakhstan (Abs 09)

2.10pm: Design and control of a parallel robot based on the

1.45pm-3.00pm
Room 3
TuP2: Vision I

Session Chair: Sunita Chauhan

1.45pm: A method of self-calibration for an active vision system; Y. F. Li; Hong Kong (Abs 12)

2.10pm: Silicon retina sensing guided by omni-directional vision; Vlatko Becanovic; Germany (Abs 13)

Design For Control approach; Cheryl Qing Li; Singapore (Abs 10)

2.35pm: Development of fibre optical switch assembly alignment machine; Nitin V. Afzulpurkar, Thailand (Abs 11)

2.35pm: Vision guidance for a climbing cleaning robot; Jian Zhu; Hong Kong (Abs 58)

3:00pm-3.20pm

Afternoon Tea/Coffee

3.20pm-5.00pm

Room 2

TuP3: Industrial applications II

Session Chair: Grantham Pang

3.20pm: Fuzzy multivariable control of a meat chiller; Peter Xu; New Zealand (Abs 018)

3.45pm: Tool calibration of a robot by force and torque sensing; Kaustubh Pathak, Thailand (Abs 16)

4.10pm: Conform extrusion gap measurement and control; K. Khawaja; UK (Abs 17)

4.35pm: Force-guided compliant motion in robotic assembly: notch-locked assembly task; Kong Suh Chin; Malaysia (Abs 15)

3.20pm-5.00pm

Room 3

TuP4: Design of mechatronic systems

Session Chair: Frank Nickols

3.20pm: Development of a novel multi-module manipulator system: dynamic model and prototype design; Clarence W. de Silva; Canada (Abs 19)

3.45pm: Prediction of parameters to avoid vehicle roll over using artificial neural networks; V Karri; Australia (Abs 20)

4.10pm: Intelligent control of a novel manipulator with slewing and deployable links; C.W. de Silva; Canada (Abs 21)

4.35pm: Imitation model of mechatronical modulus of motion; Korgan Sholanov; Kazakhstan (Abs 22)

5.00pm: Robust input-output linearisation of uncertain nonlinear affine systems: a Survey; C K Li; Hong Kong (Abs 31)

6.30pm-9.30pm

Khun-Toke Dinner (Thai northern style+performance) at Old Chiang Mai Culture Centre

Wednesday 11th September

9.30am-10.15am

Room 1

Plenary Session II

Session Chair: Robin Bradbeer

The future of Mechatronics

John Billingsley; University of Southern Queensland, Australia (Abs 23)

10.15am-10:35am

Morning Tea/Coffee

10.35am-12.15pm

Room 2

WeA1: Mobile Robotics II

Session Chair: Robin Bradbeer

10.35am: A new beacon-based system for the localisation of moving objects; Eduardo Zalama; Spain (Abs 24)

11.00am: Navigation and localszation devices and the concept for mobile robots; Carsten Hillenbrand; Germany (Abs 27)

11.25am: Modelling of unmanned ground vehicles with on-board closed-chain manipulator, for increased autonomy; Yahya H. Zweiri; UK (Abs 26)

11.50am: Space and time sensor fusion and multi-sensor

10.35am-12.15pm

Room 3

WeA2: Medical and telerobotic applications

Session Chair: Pensiri Tongpadungrod

10.35am: A mechatronic system for non invasive treatment of the breast tumours; Sunita Chauhan; Singapore (Abs 28)

11.00am: Multi-purpose autonomous robust carrier for hospitals (MARCH): design and implementation; P Sooraksa; Thailand (Abs 29)

11.25am: Gesture recognition for commanding robots with the aid of mechatronic data-glove and hidden Markov model; K. P. Liu; Hong Kong (Abs 30)

integration for indoor mobile robot navigation; Tae-Seok, Jin; Korea (Abs 25)

12:15pm-1:30pm

Lunch

Chinese Buffet

1:30pm-3.10pm

Room 2

WeP1: Human Interaction

Session Chair: Peter Xu

1.30pm: Development of a Chinese character calligraphy robot; Fenghui Yao; Japan (Abs 32)

1.55pm: Automated people counting using template matching and head search; Grantham Pang; Hong Kong (Abs 33)

2.20pm: Vision-based human-robot communication system; A.Z. Kouzani; Australia (Abs 34)

2.45pm: A mobile robot with enhanced gestual abilities; Salvador Dominguez Quijada; Spain (Abs 35)

1:30pm-3.10pm

Room 3

WeP2: Mobile robotics I

Session Chair: Stuart McCarthy

1.30pm: Using multicarrier modulation in an ultrasonic data link to communicate with an underwater vehicle; T M Law; Hong Kong (Abs 36)

1.55pm: Reactive agent architecture for underwater robotics vehicles; J.H. Ho; Singapore (Abs 37)

2.20pm: A study on the control of AUV's homing and docking; Kyu-Hyun Oh; Korea (Abs 38)

2.45pm: Autonomous mobile robot with flexible locomotive mechanism; Maki K. Habib; Malaysia (Abs 39)

3.10pm-3.30pm

Afternoon Tea/Coffee

3.30pm-5.10pm

Room 2

WeP3: Manipulator and actuator design

Session Chair: Tim Gale

3.30pm: Design of gravity compensation system for flexible structure mounted manipulators; Theeraphong Wongratanaphisan; Chiang Mai University, Thailand (Abs 40)

3.55pm: Design of a sliding mode model following control (SMFC) for DC servomotor drivers; Phongsak Phakamach; Thailand (Abs 41)

4.20pm:On-line evolution of robot program using a memoised function; Worasait Suwannik; Thailand (Abs 42)

4.45pm: Passive forces in fixturing and grasping; Michael Yu Wang; Hong Kong (Abs 43)

3.30pm-5.10pm

Room 3

WeP4: Mechatronics Education

Session Chair: Theeraphong Wongratanaphisan

3.30pm: An educational tutorial for an autonomous omni-directional six-legged beetle robot; Frank Nickols; Singapore (Abs 45)

3.55pm: Modern mechatronic curriculum for multidisciplinary engineering education; Tim Gale; Australia (Abs 46)

4.20pm: ROCON – A virtual construction kit, visualisation tool and remote control system for mechatronic devices; Joerg Kaiser; Germany (Abs 47)

6:30pm-9.30pm

Conference Banquet at Amari Rincome Hotel

Thursday 12th September

9.30am-10.15am

Room 1

Plenary Session III

Session Chair: John Billingsley

Underwater robotics research at CityU Hong Kong

Robin Bradbeer; City University of Hong Kong, Hong Kong (Abs 48)

10:15am-10.35am

Morning Tea/Coffee

10.35am-12.40pm

Room 2

ThA1: Agriculture and Food II/Sensors

Session Chair: John Billingsley

10.35am: Real time inspection of beans using a line scan camera; Taeho Kim; Korea (Abs 49)

11.00am: Control of the sugar cane harvester topper; Stuart McCarthy; Australia (Abs 50)

11.25am: Mechatronics and robotisation in agriculture; Maki K Habib; Malaysia (Abs 51)

11.50pm: An efficient distributive tactile sensor for recognising contacting objects; P.Tongpadungrod; Thailand (Abs 52)

12.15pm: CAD based automatic surface scanning using optical range sensors; Fernando A. Rodrigues Martins; Porthugal (Abs 53)

10.35am-12.40pm

Room 3

ThA2: Vision II

Session Chair: Mark Phythian

10.35am: Measuring flank tool wear on cutting tools with machine vision – a case solution; Tilo Pfeifer, Germany (Abs 54)

11.00am: Imaging through moving scattering media: comparison between averaging and "or minimum" methods; E. Juliastuti Mustafa; Indonesia (Abs 14)

11.25am: Using a panoramic camera for 3D head tracking in an AR environment; B.Giesler; Germany (Abs 56)

11.50am: An improved genetic algorithm for affine invariant shape matching scheme based on floating point chromosome representation; W.H. Tsang, Hong Kong (Abs 55)

12.40pm-2.00pm

Lunch Western-style Buffet

2.00pm-3.40pm

Room 1

ThP1: Special Invited Session MEMS

Session Chair: Bing Luk

2.00pm: Automated micro-assembly of MOEMS by centrifugal force; King W. C. Lai; Hong Kong (Abs 59)

2.20pm: Haptic tactile feedback in teleoperation of multifingered robot hand; Yantao Shen; Hong Kong (Abs 60)

2.40pm: On-line model learning for robotic manipulations; Yu Sun; USA (Abs 61)

3.00pm: Better transport protocol for internet-based teleoperation; Peter Xiaoping Liu; Canada (Abs 62)

3.20pm: A PVDF-based micro-Newton force sensing system for automated micro-manipulation; Carmen K M Fung, Hong Kong (Abs 63)

3.40pm-4.00pm

Afternoon Tea/Coffee

4.00pm-4.30pm

Room 1

Closing Session

Session Chairs: John Billingsley, Robin Bradbeer, Theeraphong Wongratanaphisan

6.30pm-9.30pm

Lake Side Dinner at Galae

Abstracts

01

Active control of internal turning operations using a boring bar; *L. Pettersson, L. Hakansson, I. Claesson and S. Olsson*; Blekinge Institute of Technology, 372 25 Ronneby, Sweden

Vibrations in internal turning or boring operations are usually a cumbersome part of the manufacturing process. The manufacturing industries are having problems with these kinds of cutting operations. When cutting in pre-drilled holes the cross sectional area of the boring bar is limited at the same time as it is long. Since a general boring bar is long and slender it is sensitive to external excitation and thereby inclined to vibrate. The vibration problem a.ects the surface .nish in particular. The demand for smaller and smaller tolerances of the surface .nish leads to that the manufacturing industry seeks for a solution to the boring bar vibration problem. The tool life is also likely to be in.uenced by the vibrations involved in a cutting operation. Another problem in boring operations is the high noise level in the cutting process. The noise level in the environment of the operators is today more and more regulated, especially in the western world. Active vibration control will reduce the amount of vibrations in the cutting operations. Since the noise is induced by the vibration of the boring bar, the noise level will also be reduced due to the cancellation of the noise source. Preliminary results show reduction of vibrations in the boring bar by up to 30dB.

02

Fabric defect classification using wavelet frames and minimum slassification error based neural network; *Grantham Pang, Xuezhi Yang and Nelson Yung*; The University of Hong Kong, Pokfulam Road, Hong Kong.

This paper presents a new method for fabric defect classification by using wavelet frames
based feature extractor and minimum classification error based neural network. Channel variances at the outputs of the wavelet frame decomposition are extracted to characterize each non-overlapping window of the fabric image, which is further assigned to a defect category with a neural network classifier. In our work, Minimum Classification Error (MCE) criterion is used in the training of the neural network for the improvement of classification performance. The developed defect classification method has been evaluated on the classification of 329 defect samples from nine types of defects and 82 nondefect samples, where an 93.4% classification accuracy was achieved.

03

Multiple robot control using force/torque and vision sensors; *Devendra P. Garg Manish Kumar;* Duke University, Box 90300, Durham, NC 27708-0300, USA

Some of the challenges that control of multiple robots present are synchronization in terms of position, motion, force, load sharing and internal force minimization. This paper presents formulation and application of a strategy for control of two six degree of freedom robots carrying an object in a cooperative mode. Vision sensor is used to determine position and orientation of object. Force torque sensors mounted on wrist of each robot provide the force and torque data in six dimensions. These data have been used in a fuzzy logic controller to achieve a cooperating movement in which one robot acts as leader and the other robot follows. Matlab's Fuzzy logic, Simulink, and State Flow toolbox are used for achieving real-time, autonomous and intelligent behavior of the two robots. Simulation results show that the above strategy was able to constrain the internal forces and provide a smooth movement of the manipulators.

04

Fully automated raw foundry brake disc dimensional characterisation and inspection through several computer vision systems; P.-M. Lerone*, J.-L. Fernández, J.-G. García-Bermejo, E.-Z. Casanova; C.A.R.T.I.F, Parque Tecnológico de Boecillo, Parcela 205, 47151- Boecillo (Valladolid), Spain

In this paper, an automatic raw foundry brake disk dimensional characterisation and visual inspection is presented, in which three different computer vision systems are used: A calibrated 3D structured-light vision system, a 3D uncalibrated structured-light vision system and a common 2D vision system. A fully automated 3D-calibration procedure is also described. The whole system is an accurately synchronised blending of mechanics, automation, computer vision and robotics. Some results from industrial implementation are presented.

05

A prototype mechatronic system for inspection of date fruits; *Abdulrahman A. Al-Janobi*; King Saud University. P. O. Box 2460, Riyadh 11451, Saudi Arabia.

A prototype mechatronic system based on machine vision has been developed for inspection and grading of date fruits. The system consisted of four integrated units, namely, the feeder, lighting system, imaging system, and grading mechanism. The feeder was a belt conveyor, which carried dates through a specially designed illumination chamber. The imaging system consisted of a personal computer equipped with a frame grabber and a colour camera. The system captured the images of the dates moving on the belt conveyor. The acquired digital images were sent to the computer for processing and the grade of the date was determined after analysing a set of features extracted from the date images. A feed forward multilayer perceptron network trained with the backpropagation algorithm was used for classification of the dates. The sorting mechanism installed at one end of the belt conveyor was operated by a TTL signal from the computer to push the graded date into the corresponding grade box. The system successfully graded samples at a rate of 2 dates/s, giving a throughput of approximately 108 kg/hour.

06

Autonomous agricultural robot; *Mark W Phythian;* University of Southern Queensland, Toowoomba Australia.

The automation of agricultural machinery in Australia has tended towards refining the operation of existing equipment

including tilling, spraying, and harvesting tasks. Little effort has been focused on developing an alternative to some of the labour intensive tasks such as weed chipping, spot spraying and crop monitoring. It is proposed that an autonomous agricultural robot, utilising recent developments in machine vision and GPS navigation, would provide a cost effective alternative to a hired hand for such repetitive tasks. This paper presents the design and current status of a robotic platform for row crop tending currently under development at the University of Southern Queensland, Australia. Details presented include the configuration of the prototype platform, control and drive systems, an overview the navigation model and the low cost GPS and vision systems.

07

The counting of macadamia nuts; *John Billingsley;* University of Southern Queensland, Toowoomba, Australia

As macadamia nuts are harvested, there is a requirement to monitor the yield. In one case, the individual yield of each tree must be determined and it is more appropriate to use counting rather than weighing. It is proposed to use machine vision to count the nuts as they are gathered. A software interface enables a digital 'webcam' style of camera to be used, an OCX control having been designed to provide image data at an adequate speed for analysis. Alternative measuring techniques are reviewed for routine harvesting.

08

Machine vision application to grading of white pepper berries; *Mani Maran Ratnam, Weng Li Khor*; Universiti Sains Malaysia, 14300 Nibong Tebal, Penang, Malaysia

This paper describes the application of machine vision to the automatic grading of white pepper berries. The pepper berries were initially graded manually into three grades based on the amount by weight of black/dark gray berries in white pepper. The vision system was used to capture front and back illuminated images for each sample from which the mean and standard deviation of the pixel gray values of the berries were extracted. These parameters were used as input to a three-layer feed-forward back-propagation neural network. By using 300 training data samples and 60 unknown test samples the prediction accuracy was found to be 96.7%. The grading carried out using discriminant analysis showed an accuracy of 95%.

09

The resolving of tasks of dynamics for control of the single planimetric multimobile manipulator; *Korgan S. Sholanov*;The Kazakh National Technical University named after K. I. Satpayev, Republic of Kazakhstan, Almaty

In the present paper power demanded for driving of a concrete six-mobile manipulator referring to single- planimetric multimobile manipulators is being defined with the he lp of an imitation model worked out especially for this purpose. Analytical apparatus of the imitation model has been devised using Newton-Euler's method in recurrent shape at local system. Numerical results have been received with imitated programme modelling application and effort dependences by drives from the structure, geometrical, kinematics and mass characteristics have been set.

10

Design and ccontrol of a parallel robot based on the Design For Control approach; *Q. Li*; Nanyang Technological University, Singapore; *F. X. Wu;* University of Saskatchewan, Canada

Parallel structure robots have been receiving growing attentions from both academia and industries in recent years. This is due to their advantages over serial structure robots, such as high stiffness, high motion accuracy and high load-structure ratio. Control of a parallel robot, however, renders a difficult problem to control engineers. To obtain the same degrees of freedom (DOF), a parallel structure is more complex than a serial one, and so is its dynamic model in general. To effectively control a complex mechanical structure for precise and fast performance, an advanced controller embedded with the system's dynamic model is usually desired. In cases of controlling parallel robots, however, the intensive computation due to the complexity of the
dynamic model can result in difficulties in the physical implementations of the controllers for high-speed performance. To avoid heavy computation, simplified dynamic models can be obtained by applying simplification techniques, nevertheless, performance accuracy will suffer due to modeling errors. This paper suggests applying an effective mechatronics design approach, i.e., the Design For Control (DFC) approach, to handle this problem. The underlying idea of the DFC approach is that, no matter how complex a system is, as long as its mechanical structure can be judiciously designed such that it can result in a simple dynamic model, a simple control algorithm may be good enough for a satisfactory control performance.

11

Development of fibre optical switch assembly alignment machine; *Nitin V. Afzulpurkar, Joan Rey V. Buot,* Asian Institute of Technology, Thailand

This paper describes the development of a fibre optical switch assembly machine to align fibre optics with an accuracy of more than 90%. The existing alignment is done by full manual operation, which is a slow and tedious. In this work we present the development of automated Fibre Optical Switch Assembly Alignment Machine Intelligent motors are used to control rotations of the axes on two sides of the machine and an extra rotation added to obtain the accuracy requirement. A kinematic four-bar mechanism is designed to transmit the motion for rotating the fiber tube. Mechanical design dynamic analysis and analytical calculation are verified using ADAMS software. The control system of motors was developed on a PC using SMI program software.

12

A method of self-calibration for an active vision system; *Y. F. Li, R. S. Lu;* City University of Hong Kong, Kowloon, Hong Kong

In this paper, we describe a calibration method for a 3D vision system using pattern projection. This calibration consists of tow phases: off-line calibration of the parameters of the pattern projector by means of the point-to-point method, and on-line calibration of the varying intrinsic and extrinsic parameters of

the camera using the line-to-point method or plane-to-point method. During the on-line recalibration, we only need to calibrate those of the two or more arbitrary light planes. The other light stripe planes' homographies relative to the camera image plane can then be recovered. By the method we can easily implement recalibration of the 3D vision system with its pattern projection when the intrinsic and extrinsic parameters of the camera are changed.

13

Silicon retina sensing guided by omni-directional vision; *V. Beèanoviæ, G. Indiveri, H.-U. Kobialka, P. G. Plöger, A. Stocker*; Fraunhofer Institute Autonomous Intelligent Systems, Sankt Augustin, Germany

A way of combining a relatively new sensor-technology, that is optical analog VLSI devices, with a standard digital omni-directional vision system is investigated. The sensor used is a neuromorphic analog VLSI sensor that estimates the global visual image motion. The sensor provides two analog output voltages that represent the components of the global optical flow vector. The readout is guided by an omni-directional mirror that maps the location of the ball and directs the robot to align its position so that a sensor-actuator module that includes the analog VLSI optical flow sensor can be activated. The purpose of the sensor-actuator module is to operate with a higher update rate than the standard vision system and thus increase the reactivity of the robot for very specific situations. This paper will demonstrate an application example where the robot is a goalkeeper with the task of defending the goal during a penalty

14

Imaging through moving scattering media: comparison between averaging and "or minimum" methods; *E. Juliastuti Mustafa, Bambang SP. Abednego*; Bandung Institute of Technology, Bandung 40132, Indonesia

In this paper, a semi transparent object illuminated with HeNe laser light is imaged using a positive lens. If there is a scattering medium between the object and the lens, the level of noise of the image can be determined with a diameter of circular spatial filter placing at the lens focal plane. The objective is then to enhance the quality of the two level of noisy image through digital processing. For this purpose, the image is recorded using a CCD camera connected to a computer. Two processing methods are considered, i.e. the averaging and the so called "or minimum" methods. Both methods were implemented by recording a number of images successively, each time with a different density of the scattering medium. This can be achieved if the scattering medium is moving. In this condition, every recorded image contains a slightly different object information. The experiment was conducted using tissue paper which is shifted along its plane to simulate the moving scattering medium.

15

Force-guided compliant motion in robotic assembly: notch-locked assembly task; *Kong Suh China, Mani Maran Ratnama, Rajeswari Mandavab*; University Science Malaysia, Penang, Malaysia

This paper presents how force-guided robot can be implemented to perform compliant motions for notch-locked assembly. A study on assembly operation of front housing and back chassis of a typical mobile phone is carried out where notch-locked assembly is involved. An assembly strategy based on three force-based compliant motions is proposed in order to perform automated assembly of front housing and back chassis of the mobile phone. The assembly strategy based on force-based compliant motion is performed and the experimental results are discussed. The implementation and the setup of force-guided robot and the end of arm tools are also presented. The system is optimized for high-speed performance while considering the constraint and limitation

16

Tool calibration of a robot by force and torque sensing; *Kaustubh Pathak, Nitin V. Afzulpurkar*; Asian Institute of Technology, Thailand

Tool calibration is the identification of a more accurate transform between the tool frame and the tool-mount frame of a robot. This transform is generally in the form of a set of offsets. We present a method of tool calibration which makes use of a force/torque sensor located on the robot's tool-mount. The tool has been modeled by a cylinder with a spherical tip. The force sensor values are first used to detect the orientation of a precision rectangular slot. Thereafter, the force sensor is used only as a touch probe to detect contact between the tool and the slot. The tool is first positioned within the slot. The offset from the initial position to contact is recorded for the three principal axes of the slot. The robot is now made to rotate about an assumed tool-centre, and the change in the contact offsets is used to improve the assumed tool-centre coordinates given in the tool-mount frame. The limitations of the apparatus, the results of the calibration procedure and the accuracy achievable are presented.

17

Conform extrusion gap measurement and control; *K Khawaja*; Holton Machinery Ltd., UK; *L Seneviratne*; King's College London, UK

The paper presents the results of a study into the automation of the Conform Extrusion process. It is critical to maintain a precise pre-defined wheel-tooling gap for the efficient running of the Conform Process and to maintain high product quality. An active high temperature gap measurement system is described and implemented on a copper Conform machine. The results from gap sensing experiments, using a capacitive sensing system, are presented. By providing an active gap control system, less flash (waste) is produced throughout the whole extrusion process. The benefits of the sensing system are discussed. A micro-controller based feedback system is being developed for providing automatic control to maintain a required gap, specified by the operator.

18

Fuzzy multivariable control of a meat chiller; *W.L. Xu, A. Cowie, G. Bright*; Massey University, New Zealand

This paper deals with modelling of meat chilling process in a freezer/chiller unit and design of a fuzzy logic controller to

control the cooling process. The entire control system was tuned and implemented in Matlab/Simulink. Simulations were carried out to test if a set of prescribed specifications have been met satisfactorily.

19

Development of a novel multi-module manipulator system: dynamic model and prototype design; *C. W. de Silva, K. H. Wong, V. J. Modi;* University of British Columbia, Canada

This paper presents the design and development of a Multi-module Deployable Manipulator System (MDMS) and a dynamical formulation of the manipulator. The system is designed for experimental investigations on dynamics and control of this variable geometry manipulator, particularly its performance under various control schemes. The manipulator planar manipulator that is developed here is somewhat unique in that it comprises four modules, each of which has one revolute joint and one prismatic joint, connected in a chain topology. The design process involves the selection and sizing of actuators, the design of mounting and connecting components, and the selection of hardware as well as software for real-time control. The dynamical model is formulated using an algorithm, based on the Lagrangian approach and velocity transformations. The algorithm is computationally efficient permitting real-time control of the system.

20

Prediction of parameters to avoid vehicle roll over using artificial neural networks; *V. Karri, H. Cunningham;* University of Tasmania, Australia

The effectiveness of artificial neural networks in prediction of vehicle parameters for roll over, using a variety of sensor data and artificial neural network (ANN) architectures, is outlined in this study in an attempt to determine its practicality for use in various controllers. To this end, the parameters to be used for ANN training and testing were chosen with regard to vehicle dynamics controllers, and the testing conditions representative of relevant driving conditions were also selected. The study also includes a description of the two ANNs used within the investigation, namely backpropagation (BP) and radial basis function neural networks (RBF). These ANN architectures were then used to gain predictions of longitudinal velocity and roll angle as parameters contributing to vehicle roll over. Provided that these predictions showed sufficient accuracy, they could then be used in vehicle dynamics control systems, at a later date, to control parameters such as brake force and engine power to prevent vehicle roll over

21

Intelligent control of a novel manipulator with slewing and deployable links; *C.W. de Silva, J. Zhang, V.J. Modi*; University of British Columbia
Vancouver, Canada

This paper focuses on the development and implementation of an intelligent hierarchical controller for the vibration control of a deployable anipulator. The emphasis is on the use of knowledge-based tuning of the low-level controller so as to improve the performance of the control system. For this purpose, first a fuzzy inference system (FIS) is developed. The FIS is then combined with a conventional modal controller to form a hierarchical control system. The effectiveness of this control system is investigated through numerical simulation studies. The results show that the knowledge-based hierarchical control system is very effective in suppressing vibrations induced due to initial disturbances at the flexible revolute joint or maneuver of a deployable manipulator. Performance of the modal controller can be significantly improved through knowledge-based tuning.

22

Imitation model of mechatronical modulus of motion; *Korgan S. Sholanov, Altyn Sh. Sagnayeva;* The Kazakh National Technical University, Almaty, Republic of Kazakhstan

In the report is offered the imitation model of Mechatronical modulus (MM) made by combining of topological model of mechanical part with control system model in the way of Petri net. The task is put to receive artificial model to get the imitation model which enables us to consider MM a controllable system with characteristic motion of energetical and informational flows resulting in consecutive and purposeful change of state. On the other hand it is necessary for the imitation model to describe adequately the dynamics of MM state. This enables to foresee the MM behavior, to choose correct control effect and carry out computer control

23

The future of mechatronics; *John Billingsley*; University of Southern Queensland, Toowoomba, Australia

That mechatronics has a future is as certain as that breathing has a future! What is in question is the way in which it will be regarded as it merges with the mainstream of engineering. Many engineers (particularly the civils!) still see it as an amalgam of diverse disciplines, but for over a decade it has been clear that the art of blending electronics, control theory and software with enough mechanical hardware to give body to the product is a discipline in itself. What is perhaps overlooked is the special nature of the 'component subjects' required by the mechatronic specialist. At an earlier M2VIP conference in hong Kong, I presented a "mechatronic cynic's" view of control theory". Electrical engineers cut their teeth on the brew of complex variables, Laplace transforms and exponentials that they need to analyse filters and electrical feedback. Not surprisingly, they see control as an extension of this theory. All too many mechatronics courses allow the electronic engineers to 'own' the subject.....

24

A new beacon-based system for the localisation of moving objects; *Eduardo Zalama Casanova, Salvador Dominguez Quijada, Jaime Gómez García-Bermejo, José R. Perán González*; University of Valladolid, Spain; Centre for the Automatisation, Robotics and Technology Information (CARTIF) Spain.

In this paper a new system for the 2D localisation of moving objects and mobile robots is presented. A rotating laser on board the moving object sweeps the surrounding space, reaching a

set of known-position beacons. Each time the light reaches a beacon, it emits a radiofrecuency identity code. The corresponding (known) beacon position, along with the actual laser angle allow the position and orientation of the object to be calculated though triangulation. The system supplies 15 localisations per second to an accuracy of 1 cm and 0.1º, which is suitable for vehicle or goods localisation in automated storehouses, or robot navigation, for example.

25

Space and time sensor fusion and multi-sensor integration for indoor mobile robot navigation; *Tae-Seok Jin, Jae-Pyung Ko, Jang-Myung Lee*; Pusan Nat'l Univ., Pusan, Korea

This paper proposes a sensor-fusion technique where the data sets for the previous moments are properly transformed and fused into the current data sets to enable accurate measurement, such as, distance to an obstacle and location of the service robot itself. In the conventional fusion schemes, the measurement is dependent on the current data sets. As the results, more of sensors are required to measure a certain physical parameter or to improve the accuracy of the measurement. However, in this approach, instead of adding more sensors to the system, the temporal sequence of the data sets are stored and utilized for the measurement improvement. Theoretical basis is illustrated by examples and the effectiveness is proved through the simulations. Finally, the new space and time sensor fusion (STSF) scheme is applied to the control of a mobile robot in an unstructured environment as well as structured environment.

26

Modelling of unmanned ground vehicles with on-board closed-chain manipulator, for increased autonomy; *Y. H. Zweiri, L. D. Seneviratne, K. Althoefer*; King's College London, U.K.

The main focus of this paper is to develop a physics-based model for a unmanned ground vehicles with onboard closed-chain manipulators (UGVOCM) in order to investigate model-based autonomous solutions for the excavation task. The model takes into account the kinematic and dynamic aspects of the mobile platform (vehicle) and the manipulator (links and hydraulic system). The model incorporates the dynamic properties of the manipulator and bucket (weight, inertia, etc.) and the dynamics of the vehicle (weight, inertia, actuator properties). Holonomic loop closure constraints are established in order to derive the closed-chain mechanism dynamics from the reduced system dynamics. The dynamic model for the excavation system is validated against measured data. The validation of the model is conducted in collaboration with QinetiQ 1. A uni.ed model is important for design of control strategies, since in the case of a front-end excavator, in order for the bucket to move, movements of the entire vehicle are required.

27

Navigation and localisation devices and the concept for mobile robots; *C. Hillenbrand, K. Berns*; University of Karlsruhe, Germany

There are several sensors for mobile robots to record they surrounding. One part of sensor are detecting there environment with cameras or ultrasonic sensor and are called absolute positioning sensor. They are calculating there position on the basis of beacons, reflectors or other environmental landmarks. The other part of sensors are relative positioning sensors. They are using internal sensors like odometrie and accelerometers to calculate there new position based on the known start position. The main problem for mobile robots are, that the sensors must be light and cheap. Finally only a few sensors are usable for mobile robots. This paper describes a tested device of accelerometers, simple gyroscope and dead reckoning wheel with a driven platform. The output of that device will be the inclination and path of the vehicle. The inclination is calculated independent of the orientation of the vehicle and any accelerations. The path is calculated with the aid of the odometrie, corrected by the internal sensors, if any sliding of the driven wheel is detected.

28

A mechatronic system for non invasive treatment of the breast tumours; *Sunita Chauhan*; Nanyang Technological University, Singapore

This paper deals with a non-invasive means, using High Intensity Focused Ultrasound (HIFU) as the surgical modality, which can be applied to ablate early or moderate stage tumours *in situ*. Present methods of breast cancer treatment are either conventional/radical mastectomy or breast conservation procedure called lumpectomy. Lumpectomy procedures are limited to early growth treatment. Both of them are invasive procedures and requires incision for access to the target tissue. For the non-invasive approach adopted in this research, the design and development of a mechatronic system operating partially in a water tank (as coupling medium) is described. The manipulator guides an end-effector consisting of an assembly of multiple HIFU transducers, through a pre-determined trajectory. A PC based controller and treatment-planning module governs various sub-sections of the system and deploys a trajectory within a safe constrained work envelope under surgeon's control. The accuracy at the endeffector tip is measured as ±0.5 mm. It is feasible to fragment the procedure and apply on an outpatient basis.

29

Multi-purpose autonomous robust carrier for hospitals (MARCH): design and implementation; *P. Sooraksa*, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand; *B. L. Luk, S. K. Tso, G. Chen*; City University of Hong Kong, Hong Kong

This paper describes the basic principles, design, and implementation of the second phase of a multi-purpose autonomous robust carrier for hospitals (MARCH) — March II. It is an autonomous robot, working as a mechatronic assistant for medical devices. The aim of the research is to develop more reliable, maintainable and intelligent functions for MARCH I. The robot is expected to be able to perform the following tasks by the end of the current phase of research: line tracking, wall following, collision avoiding, remote operating, communicating (with the central unit), navigating, and even entertaining (the elderly and children, with games, music and VOD). Hierarchical control with subsumption architecture and various intelligent control schemes is employed to enable

progressive system development and achievement of the MARCH II objectives. Experiment of mechatronic and visual subsystems have been carried out to validate the system.

30

Gesture recognition for commanding robots with the aid of mechatronic data-glove and hidden Markov model; *K. P. Liu, S. K. Tso and B.L. Luk*; City University of Hong Kong, Hong Kong

This paper describes the design of a gesture-recognition system for commanding robot toys with the aid of a low-cost mechatronic data-glove and the HMM technique. The mechatronic dataglove consists of a pair of orthogonal 2-D acceleration sensors that can measure acceleration in the xy- z directions. Since the gesture is recorded in the form of noisy acceleration data, wavelet-filtering technique is applied to smooth the data, and the velocity is calculated by integrating the smoothed acceleration data. The velocity profile is then transformed by the short-time discrete Fourier transform (STDFT) so that the time-domain profile is represented by a sequence of frequency spectrum vectors, which are more suitable for shape comparison. After the spectrum vector units are quantized to a finite number of symbols called observation sequence, it can be modeled and represented by HMM. Then the gesture comparison and recognition is done by evaluating the observation sequence by all HMMs used to represent all the selected prototype gesture.

31

Robust input-output linearisation of uncertain nonlinear affine systems; *C.K. Li, Hongmin Chao, Yueming Hu*, The Hong Kong Polytechnic University, Hong Kong; *A.B. Rad* South China University of Technology, Guangzhou, China

This paper deals with robust input-output linearisation of uncertain nonlinear affine systems. It first discusses robust input-output linearisation of uncertain nonlinear systems with relative degree defined. As for those systems with relative degree undefined, it first uses dynamic extension to achieve the system relative degree; and then deals with robust input-output linearisation of the extended system. This paper also gives the generalised matching conditions for the above systems to realise robust input-output linearisation.

32

Development of Chinese character calligraphy robot; *Fenghui Yao, Guifeng Shao, Ryoichi Takaue, Akikazu Tamaki*; University of East Asia, Seinan Gakuin University, Japan

This paper describes a Chinese character calligraphy robot that can be categorized as an art robot. The whole system consists of a calligraphy dictionary, robot arm, robot hand, writing brush and system controller. The calligraphy dictionary includes five styles of Chinese character image patterns written by famous calligraphers in Chinese history. When the character to be written and the style are given, the system starts to search the calligraphy dictionary, and outputs all image patterns registered in the dictionary for the assigned character. Then, the contour detection and thinning are performed, based on the character image pattern designated from the output image patterns. These two features, together with writing order information, are sent to the robot to write character as the human calligrapher does. The aim of this work is, firstly, to teach calligraphy skills to the robot, and secondly in turn, in order to preserve the character calligraphy culture, have the robot teach the beginner calligraphy skills.

33

Automated people counting using template matching and head search; *Grantham Kwok-Hung Pang, Chi-Kin Ng,* The University of Hong Kong, Hong Kong.

People counting using image processing has been carried out for years. Conventional methods can count people accurately when only a few isolated people pass through a counting region in a non-crowded situation. In this paper, the emphasis is on people counting in a crowded environment and a method using head search and model matching is described. A camera is mounted vertically downwards viewing the people heads from the top. People head search can be used to locate some passengers. In addition, templates obtained from the perspective projection of the human model are used to locate and isolate individual person. Our approach aims at dealing with a congested situation where occlusion is a major problem. This paper describes a real-time, high-accuracy, automated people counting system that has been developed. Experimental results are illustrated and the effectiveness of the developed method for real-time application is verified.

34

Vision-based human-robot communication system; *A.Z. Kouzani*; Deakin University, Australia

A method is presented to analyse facial expressions in images obtained by a camera. The system can be employed in a humanoid or a home robot enabling the robot to receive commands form a person, or to perceive the person's mood or intention. A global-local decomposition of the image under examination is implemented in the proposed system; then the facial expression is recognized by the system. The proposed system together with five existing counterparts are implemented to compare their relative performances for expression analysis. Experimental studies are reported, and a comparison with the five existing techniques is presented.

35

A mobile robot with enhanced gestual abilities; *Salvador Dominguez Quijada*, Centre for the Automatisation, Robotics and Technology Information (CARTIF) Spain. *Eduardo Zalama Casanova, Jaime Gómez García-Bermejo, José R. Perán González*, ETSII, University of Valladolid, Spain

This paper shows the development of a mobile robot with expressive capacity for its use as tourguide robot in a museum. The system is composed of a wheeled platform and a robotic head which can perform different facial expressions: happy, sad, angry, frightened, astonished, etc. using a caricatured face and speech generation.

36

Using multicarrier modulation in an ultrasonic data link to communicate with an underwater vehicle; *Eric T M Law, Robin Bradbeer, Lam F Yeung, Li Bin, Gu ZhongGuo, Tom H T Kwan*; City University of Hong Kong, Hong Kong; Northwestern Polytechnical University, Xi'an, China

Most current underwater remote operated vehicles (ROV) are controlled using data sent along an umbilical link to a base station. These umbilical cables cause problems with the control of the vehicle. This paper describes the prototype of an ultrasonic communications system that dispenses with the umbilical and uses an ultrasonic modem to transmit colour, still and video, pictures, as well as data, to and from such an ROV.
The system described in this paper uses Multicarrier Modulation, and has been successfully tested at a data rate up to 10kbps over 1km. The system algorithm generates 48 frequencies for transmitting 48 parallel bits of data in each packet. A long transmitted signal sequence is combined with synchronisation, zero gap and information packets. The long multi-frequency signal packets have been implemented to minimise the effect of multipath fading, which is a particular problem in shallow,
open water environments. Experimental results from sea-trials have shown that the system can cope with multipath fading environments.

37

Reactive agent architecture for underwater robotic vehicles; *J.H. Ho, G. Seet, M.W.S. Lau, E. Low*, Nanyang Technological University, Singapore

This paper describes a reactive agent architecture for Underwater Robotics Vehicle (URV) which could be incorporated into a control system in supervisory mode. An agent can be described as a software object that is capable of task delegation, data-directed execution, communication and planning. Agents can be designed to help pilots in structured tasks such as pipeline tracking and moving to an absolute position. The reactive system operates in a sense-decide-act cycles where agents receive sensing data from the sonar system and produce planning results for the pilot module. Agents in the architecture are divided into two layers, namely the mission level and the basic level. The mission level consists of agents designed specifically for a particular task. The basic level incorporates the sense-decide-act events. Simulation was carried out to verify algorithms in the reactive system and promising results were obtained.

38

A study on the control of AUV's homing and docking; *Kyu-Hyun Oh, Jung-Yup Kim, Ill-Woo Park, Jungho Lee and Jun-Ho Oh;* Korea Advanced Institute of Science and Technology, Taejon, South Korea

AUV(autonomous underwater vehicle) is un*manned und*erwater vessel to investigate sea environment and resources. To be completely autonomous, AUV must have the ability to home and dock to the launcher. By the way, there are many system uncertainties in AUV modeling and disturbances in the deep sea. So, due to these difficulties, robust control is much necessary to control AUV. Therefore, a sliding mode controller is selected and designed to regulate and track any suggested paths to accomplish the homing and docking procedure. Because AUV system has the non-matched uncertainties, an established idea is applied to solve this problem. Next, by the appropriate cost functions and algorithms, the homing and docking paths are generated in a space. By using these paths, we simulate lane changing problem and the docking procedure in the presence of the ocean current and waves.

39

Autonomous mobile robot with flexible locomotive mechanism; *Maki K. Habib;* Monash University, Selangor, Malaysia.

In order to have good mobility over uneven and rough terrain a legged robot seems to be a good solution. However legged robots are usually slower and have a lower load/power ratio with respect to wheeled robot. In addition walking robots present many important control problems This initiates a challenge to investigate the technical problems involved in the realization of a robot that use legs to navigate in difficult and partly unstructured environments. To tackle these research topics, there is a need to develop and implement a legged robot that can be used as a test-bed for research purposes. The objectives of this paper are to design, model and simulate a small, modular six-legged autonomous mobile robot called 'URUK' and highlight its controller
requirements. Each leg of the developed constitutes three degrees of freedom. The robot is to be integrated with different types of sensors that facilitate its performance while interacting with its environment and avoiding obstacles. The concluded objectives aim to develop a flexible locomotive mechanism for the robot to enable the generation of reliable gait that enhance stability and mobility during navigation.

40

Design of a gravity compensation system for a flexible structure mounted manipulator; *Theeraphong Wongratanaphisan, Meng Chew, Thongchai Fongsamootr*; Chiang Mai University, Thailand, Lehigh University, USA

This paper presents the design of a gravity compensation system for a flexible structure mounted serial manipulator. The purpose of the study is twofold: 1) to construct a gravity compensation system that ideally eliminates the eects of gravity on a robot manipulator while using least amount of power; 2) to apply the gravity compensation concept to a manipulator that is mounted on a flexible structure. First, a passive gravity compensation system was designed to counteract gravity forces in any posture of the manipulator. This was accomplished by using spring suspension with special setup. Under the compensation of gravity, the manipulator behaves as if it were in the space. Electively the gravity induced torque are completely compensated for. Therefore the power of the actuators needed to carry out a specified task is minimized.
Second, the gravity compensation system was applied to a manipulator that operates on a flexible platform. In general, the dynamics of the manipulator and the flexible structure are coupled. Therefore as the manipulator moves during performing its tasks, its dynamic excites the vibrational modes of the flexible structure. As the manipulator's base is in

vibration, the end-point accuracy is disrupted.

41

Design of a sliding mode model following control (SMFC) for DC servomotor drivers; *P. Phakamach, W. Sa-niamsak, V. Charnprecharut*; North Eastern University, Muang Khonkaen, Thailand.

The design of a Sliding mode Model Following Control or SMFC strategy for a position control of DC servomotor driver are presented. The SMFC algorithm uses the combination of model following control and sliding mode control to improve the dynamics response for command tracking. A design procedure is developed for determining the control function, the coefficients of the switching plane and the integral control gain such that the error between the state of the model and the controlled plant is to be minimized. The control function is derived to guarantee the existence of a sliding mode. The chattering in the control signal is suppressed by replacing the sign function with a modified continuous function. Simulation results illustrate that SMFC can essentially eliminate the steady state tracking error due to a ramp command signal, while the MIVSC and IVSC strategies give a substantial error. Also, its can achieve a rather accurate servo tracking and is fairly robust to plant parameter variations and load disturbances.

42

On-line evolution of robot program using a memoised function; *Worasait Suwannik, Prabhas Chongstitvatana,* Chulalongkorn University, Bangkok, Thailand

This work proposes a memoized function to speed up on-line evolution of robot programs. On-line evolution is performed on a physical robot. It has an advantage over an off-line method as being robust and does not require the robot model. However, on-line evolution is very time consuming. To validate our proposal, an experiment with visual-reaching tasks is carried out. The result shows that the memoised function can speed up on-line evolution by 23 times and the resulting control program performs robustly.

43

Passive forces in fixturing and grasping; *Michael Yu Wang*; The Chinese University of Hong Kong, Hong Kong

Analysis and characterisation of contact forces are important in fixture design and robotic grasping since they define the object stability during fixturing or grasping. This paper presents a description of passive forces arising at the normal and frictional contacts by passive physical means. The passivity nature requires application of the minimum norm principle to solve a constrained quadratic optimisation in order to determine the passive contact force. The model reveals some intricate properties of the passive contact forces, including internal passive forces. Further, a notion of hybrid force closure is considered to characterise the passive nature of the hybrid forces. The hybrid force closure conditions and their implications in practice are illustrated with an example.

44

Withdrawn

45

An educational tutorial for an autonomous omni-directional six-legged beetle robot; *F. Nickols*; Nanyang Technological University, Singapore.

A tutorial is described for the teaching of microprocessor real-time programming, parallel processing, numerical analysis and algorithm development, artificial intelligence, behaviour robotics, kinematics of linkages, sensors, actuators and mechanical systems. The tutorial manifests itself as a desk-top sized autonomous six-legged robot beetle. and can be used to teach students ranging from 14 year-old school children up to university level graduate students.

46

Modern mechatronic curriculum for multidisciplinary engineering education; *T.J. Gale, V. Karri*; University of Tasmania, Australia

Mechatronics Engineering is playing an increasingly significant role in industry and universities are responding by developing courses to meet the demand from both the industries concerned and the students themselves. Our focus is this regard is primarily related to mechatronics in the manufacturing industry. The continued success of manufacturing technology, as a key part of recent industrial revolution, is in part due to many inherent advantages and technological capabilities covering a wide spectrum of both managerial and technical skills. While mechatronics may be defined as a synergetic integration of Electrical/Mechanical Engineering, modern universities are constantly structuring such courses to cater for dynamic industry needs. In recent times the ability to combine high precision machine tools to electronics and computer technology has enabled modern manufacturing to be computer controlled and lead the way towards programmable automation and a 'revolution' in computer based manufacturing.

47

ROCON – A virtual construction kit, visualisation tool and remote control system for mechatronic devices; *Jörg Kaiser, Thomas Fries*; University of Ulm, Germany

ROCON (RObot visualisation and CONtrol system) is an integrated virtual construction, visualisation and control tool for complex mechatronic devices ROCON allows to built virtual robots from geometric elements connected by rotational and linear actuators. It also includes the facility to define sequences of motion patterns to explore the complex mechanical constructions. Additionally, ROCON enables the control of a physical equivalent by generating the necessary control signals derived from the simulation. This can be exploited for remote robot control. Sensor information from a real robot which is fed back to the visualisation system supports the presentation of a realistic view of the robot, particularly concerning orientation in space which can not be derived from the visualisation only.

48

Developments in underwater robotic systems at CityU; *Robin Bradbeer;* City University of Hong Kong, Hong Kong;

The Underwater Systems Laboratory was established at CityU

in 1996. It is centred around a water tank test environment that is unique in southern China. During the past 6 years a number of projects have been completed, including an autonomous underwater platform, a pipe inspection robot, and an ultrasonic-based underwater communications system. This seminar will give a brief overview of these projects and the technology that has been developed, as well as a look at current work, including an underwater ROV, and that planned for the future. The presentation will be basically descriptive in content.

49

Real time inspection of beans using a line scan camera; *T. Kim, Y. Seo, Y. Do*; Daegu University, Kyungsan-City, Korea

An automatic bean inspection system is designed. Beans conveyed by a belt are inspected by a black and white line scan camera and those determined as bad ones are ejected by air guns. Mechanically the key issue of the system design was with making beans flow steadily following predetermined paths from the feeder to collecting boxes passing across the scanning line of a camera. The vision part was programmed to do inspection in real time based on parameters learned automatically from some manually sampled good beans. The parameters used were the gray level distribution and surface smoothness of a bean. In an experiment with yellow beans, the correct decision rate of inspection was about 94% in the processing speed of 520kg/hr.

50

Control of the sugar cane harvester topper; *Stuart G. McCarthy, John Billingsley*, *Harry Harris*; University of Southern Queensland, Australia

Operation of a mechanical sugar cane harvester is a skill and labour intensive task. The operator has many functions to manually control under difficult conditions. The focus of this paper will be one of these functions: the topper. The height at which the topper cuts the cane stalk has a considerable effect on the quality of the product, and ultimately the return to the grower. A sensor has been constructed that will measure and return a real-time signal of the height of cut on the cane stalk by the topper. It is proposed that that the introduction of some form of closed loop control system for the topper may reduce the responsibility of the harvester operator.

51

Mechatronics and robotisation in agriculture; *Maki K. Habib*; Monash University (Malaysia Campus), Selangor, Malaysia

The role of robots and other intelligent machines in agriculture is increasing as they are contributing to enhance productivity and efficiency of field operations while leading to larger field sizes and sophisticated machinery. Agriculture is a ripe, relatively unexploited application opportunity with uncommon advantages for commercialising mobile robotics technology. Such vehicles have to work in a challenging environment related to wide range of applications such as harvesting, irrigation, safety, quality evaluation, plant diagnosis, weed detection, etc.
Advances in micro-technology, microprocessors, sensor technology, signal processing and communication technologies, and biological inspiration in learning and decision-making capabilities have led to breakthroughs in the invention of a new generation of robots called service robots. The new types of robots aim to achieve a high level of flexibility, adaptability, mobility and efficiency to perform variety of tasks. Intelligent machines must be capable of sensing the environment and properties of the biomaterials, which it is handling

52

An efficient distributive tactile sensor for recognising contacting objects; *P.Tongpadungrod*, King Mongkut Institute of Technology North Bangkok, Thailand; *P.N.Brett*, University of Aston, Birmingham, UK

This paper describes a novel distributive tactile sensor for the discrimination of object shape. The distributive approach uses the coupling information between sensing elements that captures changes in properties of a common tactile surface to infer contact types. It offers a reduction in the number of sensing elements compared to the mainstream discrete type sensors.

53

CAD based automatic surface scanning using optical range sensors; *F. A. Rodrigues Martins*, Polytechnic Institute of Leiria, Portugal; *J. Gómez García-Bermejo, E. Zalama Casanova, J. R. Perán González*, University of Valladolid, Spain

The focus of this paper is surface scanning automation based on a *priori* known information from a CAD model and using optical range sensors. The proposed approach is divided in two distinct phases: viewpoint set planning and scanning path generation. A 3D voxel map generated from the object CAD model is used as the basic data structure for both problems. Optimal viewpoints are computed according to high accuracy surface coverage and surface scanning cost criteria. A surface following scheme is used to define collision free and efficient scanning path trajectories. Experimental results show that the proposed approach is capable of measuring automatically and efficiently the surface of a known object. A five dof positioning system was used to perform the tests but the approach is sufficiently general to be used in distinct systems set-up with distinct dof.

54

Measuring flank tool wear on cutting tools with machine vision – a case solution; *Tilo Pfeifer, Dominic Sack, Alexandre Orth*, RWTH, Aachen, Germany; *Marcelo R. Stemmer, Mário L. Roloff*, Federal University of Santa Catarina (UFSC), Florianópolis – SC – Brazil

The market has changed significantly over the last years. Nowadays, industries must deal with extremely demanding customers. In order to stay in business, they have to develop quickly customized and specialized products with low prices. In this sense, process monitoring is of crucial importance as it optimises the productivity and reduces the costs by avoiding the production of scrap as well as improving the final product quality. Flank wear is an important parameter in chip forming processes – it allows to estimate the cutting tool's lifetime and to control the product quality. There are many different types of cutting tools, differing one from the other according to the

type of machining processes (milling, drilling, etc.), the tool's geometry and its material characteristics. These properties influence directly the optical characteristics of cutting tools. Therefore the design of a machine vision system for this application is a complex task. This paper describes the development of a image processing system to measure the flank wear and classify the tool wear type (broken tool, flank wear, ...).

55

An improved genetic algorithm for affine invariant shape matching scheme based on floating point chromosome representation; *W.H. Tsang*, Thomson Multimedia (Hong Kong) Ltd., Hong Kong; *P.W.M.Tsang, Zhang Yu* City University of Hong Kong, Hong Kong.

It has been proven that the task of matching a pair of object images could be encapsulated as the search for the existence of an Affine Transform to describe the geometrical changes between the two subjects. Recently, Simple Genetic Algorithm has been attempted to conduct the search and the results reflect the feasibility of the approach. Despite the moderate success, failure rates are sometimes significant for complicated and nonlinear search landscapes. In this paper, a method based on Floating Point Genetic Algorithm (FPGA) and an alternative Affine Transformation representation is presented to overcome the aforementioned problem. Experimental results demonstrate that the proposed matching scheme has attained satisfactory success rate in identifying incomplete edge images that are contaminated with certain degree of background noise.

56

Using a panoramic camera for 3D head tracking in an AR environment; *Björn Giesler, Tobias Salb, Rüdiger Dillmann*, IAIM, University of Karlsruhe (TH), Germany; *Tim Weyrich*, ETH Zürich

For Augmented Reality using a pair of transparent 3D glasses, a precise and fast method for head tracking is required, to determine the user's position and direction of gaze in all six degrees of freedom. The methods currently available require expensive external sensors and have small working areas and/ or other limitations. We propose a method that uses a panoramic camera that is mounted directly on the user's head, combined with cheap, easily mountable passive artificial landmarks. The panoramic camera uses a paraboloid mirror, which allows for interesting algorithmic simplifications. The system has been tested both in simulation and in reality and shows promising results.

57

Withdrawn

58

Vision guidance for a climbing cleaning robot; *Jian Zhu, Dong Sun, Shiu-Kit Tso*, City University of Hong Kong, Hong Kong; *James K. Mills*, University of Toronto, Canada

This paper describes a visual sensing application of a climbing robot that provides cleaning service on the glass wall of high-rise buildings. The vision system, mainly composed of an omnidirectional CCD camera and two laser diodes, is used to perform the real-time measurement of the robot position on the glass surface and location of the dirtiness to be cleaned. The mathematical model and the measure methodology of the vision system are discussed in this paper. An experiment is performed to calibrate the visual sensor, which is followed by measurement of the position and the location of the dirtiness. The experimental results verify the effectiveness of the proposed

59

Automated micro-assembly of MOEMS by centrifugal force; *King W. C. Lai, Wen J. Li;* The Chinese University of Hong Kong

Due to the minute scale of MEMS, inertia forces are often neglected. However, we have proved that these forces can be significant even if a microstructure's mass is <1mg (a 250μmx100μm mass with MUMPs poly1, poly2, and Au layers). We have demonstrated that at this scale, mass inertia force can overcome surface forces and be used for non-contact self-assembly of MEMS structures. Centrifugal force was applied to hinged MUMPs#43 structures, causing these structures to self-assemble by rotating themselves 90^{o} out of substrate plane and automatically locked themselves to designed latches. This batch-assembly technique is very fast, low-cost, non-contact, and non destructive. Moreover, we have successfully experimental characterised the centrifugal forces needed to assemble these microstructures by integrating sensors on the same MUMPs chips to provide wireless signal that relate to the dynamic behaviour of the microstructures. This is a very important outcome in terms of making feasible quantitative analyses of surface forces acting on surface micromachined MEMS devices. Our current results will be reported in this paper.

60

Haptic tactile feedback in teleoperation of multifingered robot hand; *Yantao Shen, Wangtai Lo, Yunhui Liu*; Chinese University of Hong Kong, Hong Kong; *Kejie Li*, Beijing Institute of Technology.

61

On-line model learning for robotic manipulations; *Yu Sun, Ning Xi, Jindong Tan*; Michigan State University, USA

In this paper, an online model learning method for the unknown environments has been developed. By the interactions between a mobile manipulator and the unknown object, a nonholonomic cart in this case, the sensory information has been collected to estimate the model parameters of the cart, which are used to control the cart. Since the raw data are contaminated by noise that can not be modeled statistically, a wavelet based Least Square Method(LSM) is proposed to estimate these parameters for the
cart. The raw signal has been decomposed into certain bandwidth to generate a series of new signals, which are used to estimate the parameters. The new signal, which has the minimal estimation residual in least square sense is adopted as the best estimation. The error convergence of the estimation approach has been given. The experimental results indicate

that the estimation accuracy can be significantly improved by the use of the proposed method.

62

Better transport protocol for internet-based teleoperation; *Peter Xiaoping Liu*, Carleton University, Canada; *Max Q-H Meng*, University of Alberta, Canada; *Simon X. Yang*, University of Guelph, Canada

For Internet-based teleoperation systems, neither of current transport protocols, i.e., TCP and UDP, works very well. In this paper, we present a novel end-to-end rate-based teleoperationoriented network transport protocol called the trinomial (á,â,ã) protocol for teleoperation systems. This protocol is able to adjust its transmission rate adaptively and properly based on real-time network states. In the steady state of the network, its transmission rate is smooth, however, when available network bandwidth varies, it adapts to the variation quickly. It presents similar performances to UDP on delays, delay jitter and packet loss rate, which are much better than those of TCP. Compared to UDP, the trinomial protocol is TCP-friendly (inter-protocol fair), intra-protocol fair and efficient. All these characteristics of the trinomial protocol are successfully demonstrated through simulation and comparison studies.

63

A PVDF-based micro-Newton force sensing system for automated micro-manipulation; *Carmen K. M. Fung, Wen J. Li* The Chinese University of Hong Kong, Hong; *Ning Xi,* Michigan StateUniversity, USA

Despite the enormous research efforts in creating new applications with MEMS, the research efforts at the backend such as packaging and assembly are relatively limited. One reason for this is the level of difficulty involved. One fundamental challenge lies in the fact that at micro-scale, micro mechanical structures are fragile and easy to break - they typically will break at the micro-Newton (mN or 10-6N) force range, which is a range that cannot be felt by human operators. In this paper, we will present our ongoing development of a polyvinylidence fluoride (PVDF) multi-direction micro-force sensing system that can be potentially used for force-reflective manipulation of micro-mechanical devices or micro-organisms over remote distances. Thus far, we have successfully demonstrated 1D and 2D sensing systems that are able to sense force information when a micro-manipulation probe-tip is used to lift a micro mass supported by 2mmx30mmx200mm polysilicon beams. Hence, we have shown that force detection in the 50mN range is possible with PVDF sensors integrated with commercial micro-manipulation probe-tips.

INDEX

(by session and first author)