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Tong Liu, Guo Fang Gong, Hua Yong Yang, Ouyang Xiaoping and Shi Zhuo.

An electro-hydraulic hybrid driving strategy for hard rock tunnel boring machine (TBM) cutterhead system was proposed to solve the inconsequence of power over-installed and inadequate driving capability of traditional pure electro-motor driving method. Firstly, the electro-hydraulic driving system was functional introduced and designed to match a 2.5m diameter TBM test rig, then the model of multiple electro-motors and hydro-motors were founded in Simulink and AMEsim respectively. Finally, using S-function described multiple gear ring meshing mechanical transmission system to connect electric and hydraulic motor, hybrid driving system was analyzed using co-simulation method. The results show that hydraulic motors could track the speed and torque of main-motor accurately, and the hybrid driving system owns significant stronger off-struck ability with lower assembled power.

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Zenghui Xie, Gangfeng Liu, Changle Li, Ge Li, Jie Zhao and Liyi Li.

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Wenjun Qiao, Bao Song, Xiaoqi Tang, Xiangdong Zhou, Bosheng Ye and Yuanlong Xie.

In this paper, a novel chattering-free hybrid control (HC) algorithm is proposed for the speed regulation of permanent magnet synchronous motor (PMSM). The HC is made up of the high-order sliding mode control (HOSMC) scheme and the proportional-integral (PI) control scheme, where HOSMC is developed for transient tracking, and PI is responsible for steady regulation. The error band method is adopted to determine the switching rule between the HOSMC and PI schemes. When the operation condition happens with strong disturbances and the tracking

error exceeds the error band, the HOSMC scheme is chosen to be the main controller due to its characteristics of fast response and strong robustness. Under the control of HOSMC, the tracking error will converge to zero gradually. However, the undesirable chattering is generated by the discontinuous and high-frequency switching control action in HOSMC scheme. On the other hand, when the amplitude of the disturbances decreases and the tracking error enters the error band, the PI scheme will replace HOSMC to be the control core such that the actual speed will track the speed reference without chattering and steady error. The main advantages of the proposed HC algorithm are that the chattering is eliminated by the PI scheme, meanwhile, the strong robustness is guaranteed by the HOSMC scheme. Real-time experiments in embedded platform are conducted to verify the efficiency and superiority of the HC algorithm.

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Chunsheng Hu and Wenjie Ding.

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Wei Sun, Honghui Ma, Lintao Wang and Xueguan Song.

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Jingmin Li, Lihua Guo, Yuancheng Li, Zhenkun Lei, Yuanchang Liu, Weiping Shi, Tao Li, Weikang Li and Chong Liu.

Open surgery is currently the main treatment method for the lumbar burst fracture with neurological deficit but may irreversibly disrupt the lumbar anatomy. The minimally invasive surgery (MIS) techniques have gained increasing attentions recently. However, their use is still limited to lumbar burst fractures mainly due to their difficulties in burst fracture reduction and decompression. Here we present a novel bio-inspired MIS device which can be used with an endoscope to reset the bone fragments retropulsed into the spinal canal within the wounded vertebral body. This study may be capable of converting the posterior open surgeries to the MIS procedures, and expands the use of the MIS techniques in the treatment of lumbar burst fractures.

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Yanbiao Feng, Zuomin Dong, Jue Yang and Rui Cheng.

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Li Ma and Changpin Li.

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Hang Zhong, Shushuai Li and Yaonan Wang.

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Paper 20

Resonance suppression of two-mass drive systems considering compensation of anti-resonance character 63

Tianhang Chen, Bao Song, Xiaoqi Tang, Jian Jin and Xiangdong Zhou.

This paper provides systematic analysis and controller design methods for high-performance two-mass drive systems. A non-parametric method is introduced to identify dynamics of two-mass drive system, especially the resonance and anti-resonance frequencies. Compared with the conventional Fast Fourier Transform (FFT) approach, the non-parametric method can easily recognize anti-resonance frequency and tolerate lower Signal-to-Noise Ratio (SNR) of measured signals. Two notch filters are tuned using the identified characters to suppress resonance, and together with simple Proportional-Integral (PI) controllers to improve the position tracking performance. Simulation and experimental results are presented to demonstrate performance improvement obtained by the proposed method.

Paper 22

Design of Integrated Architecture of Web Service-Based Diagnosis System for TBM 69

Lin Li, Yixiang Huang, Chengliang Liu, Haidong Yu, Jianfeng Tao and Yajin Wu.

Tunnel Boring Machine (TBM) is widely utilized in tunnel construction. Effective analysis for the failure of TBM is vital for the safety of tunnel boring since the failure of TBM might cause severe time and economic loss. This paper proposed a Web Service-Based Remote Diagnosis System (WSRDS) with Bayesian network (BN) as the faults analysis model which is a concise, practical and intuitive method to determine the exact cause for failure. The WSRDS enables an easy access for the diagnosis system of TBM and highlights an enhancement to the ubiquitous information processing. Taken the thrusting system of TBM as an example, the architecture of the WSRDS is formulated and the function of every module is described. The key system modules including general diagnostic procedure and

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Paper 23

Improved Fokker–Planck analysis of random excited piezoelectric bimorph energy harvester N/A

Xiaoya Zhou, Shiqiao Gao and Haipeng Liu.

This work focuses on an improved Fokker–Planck (FP) method for a piezoelectric bimorph energy harvester subjected to random excitation. Compared with experimental results, the theoretical natural frequency and equivalent stiffness of vibrator are given. Analytical solutions of the output power and voltage are derived from the improved FP method, which can also be applied to nonlinear energy harvesters. Monte Carlo simulation and experiment are both consistent with the improved FP theory, proving that spectrum density (SD) of acceleration, load resistance, piezoelectric coefficient and natural frequency value have an effect on output characteristics.

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Sun Wei, Zhu Ye and Wang Wei Zheng.

As a key component of the full face rock tunnel boring machine (TBM),Due to complicated geological conditions and variable tunneling parameters, cutterhead endures multi-point random impact loads, in many projects, As a result, some engineering faults may appear, such as severe vibration, abnormal wears of cutting tools, cracking of cutterhead panel and the seal failure of main bearing, The lack of vibration evaluation systematic was the main reason of the failure.A evaluation system has been established from the vibration regarding the situation.A multi-hierarchy evaluation system has been established from the vibration regarding the situation,which,established dynamics equations by finite element method, regarded the value of the three-direction velocity of the key locations as the vibration severity index. Taken the TBM cutter-head of Jilin diversion engineering as an example , it’s shown as follows:And 4.3 mm/s,3.2 mm/s are the value of vibration severity separately the locations of cutter saddle welding and flange bolt joint welds.Vibration severity of the cutter-heads can meet the requirements by calculating,but is need to be improved.

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Piyu Wang and Qingsong Xu.

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together as a zero-stiffness structure in each working direction. A complete elliptic integral model of the zero-stiffness structure is established and verified by using finite element analysis (FEA) simulation. The structure parameters are carefully designed to guarantee the requirement on motion range, stiffness, resonant frequency, and payload capabilities. The parametric design is verified by conducting FEA simulation, which reveals a reachable constant-force motion range about 700 μm in each working axis with good performance in other aspects.

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Design and Implementation of a Novel Weaving Machine for 3D Non Crimp Fabric 87

Hu Xudong, Ying Zhiping, Yuan Yanhong and Wu Zhenyu.

By using of binder yarn in weaving process, the 3D woven reinforced composites have attracted lots of attentions due to their excellent delamination resistance. It is most suitable for special fibers such as carbon fiber, grass fiber, and aramid fiber. In this paper, a novel weaving machine including multi shedding mechanism, warper creel, weft insertion motion and beating-up motion is designed to manufacture the 3D non-crimp fabric (NCF). In the multi shedding mechanism where carbon or glass fiber is employed as the reinforced material, the harness frames in shedding mechanism are independently actuated by servo motor to form particular shedding structure, which carry the binder yarn to obtain corresponding fabric pattern. The yarn creel and two-pillar tensioners are used to release the yarns with specific tension. The weft insertion motion is also designed to realize multilayer reciprocating motion simultaneously with adjustable tension. The beating-up forces can be regulated by adjusting the stroke of reed. Screw rod driven by servo motor is adopted to taking-up to achieve adjustable weft density. Moreover, the Programmable Logic Controller (PLC) is involved in the design for controlling the weaving loop such as shedding, beating-up force and weft density. These operating parameters can be configured on-line to produce the 3D non-crimp fabric rapidly. The study discussing the design and control about the 3D weaving machine in detail has important implications for manufacture of fiber reinforced composite structure.

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Junbo Lei, Jianfeng Tao, Chengliang Liu and Yajin Wu.

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Model-Based Micro-Grid Modeling and Optimal PEV Charging Control 97

Luting Wang, Chong Cao and Bo Chen.

Micro-grid systems can support distribution network to avoid insufficient electricity supply by effectively integrating renewable energy sources and energy storage systems. This paper studies the modeling of a micro-grid system using SimPowerSystems in Matlab/Simulink environment. The Micro-grid consists of ten Electric Vehicle Service Equipment (EVSE), a Photovoltaics (PV) farm, an Energy Storage System (ESS), and a commercial building. To minimize charging cost as well as limit the micro-grid peak load, the Non-Integer Generic Algorithm (NIGA) optimization method is used to obtain optimized Plug-in Electric Vehicle (PEV) charging/discharging schedule with time-varying charging rate. The time-of-use (TOU) price and discharge incentive are applied to implement the cost minimization. The simulation results show that the total load is flattened corresponding to TOU price structures. The optimization that considers both discharge incentive and microgrid load limit can generate a cost-power win-win result.

Paper 30

The effect of different shapes of cantilever beam in piezoelectric energy harvesters on their electrical output N/A

Lei Jin, Guangyi Zhang and Shiqiao Gao.

In this work, for an arbitrary shape (i.e. the width can be described by an arbitrary function) beam, some analytical models for vibrations and electric output are established. To verify the models, some experiments are also conducted. From the theoretical and experimental analyses, it can be seen that, for a given excitation acceleration, the total charges on the electrode surface are seems to nearly not affected by the shapes or the width of the beam. The shapes and widths will affect directly the capacitance of the piezoelectric layer, and then affect the open circuit output voltage.

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An electromechanical coupling model of TBM's main driving system 103

Hanyang Wu, Junzhou Huo, Wei Zhang, Dong Zhu and Nan Hou.

The damage in driving system's core part of TBM caused by pinions' asymmetrical load is very serious. The traditional design lacks the coupling relationship between the mechanical and control system, which leads to the bottleneck of the TBM's driving system's symmetry. This paper considers the dynamic character and control system of the TBM's driving system. An electromechanical coupling model is proposed based on torque's in-time interactive. Take the engineering project as example, the calculation was proceeded based on the original model. The result shows that after a gear frequency cycle, the torque of the motor with maximum load increased by 4.46%, and the minimum one decreased by 9.00%.

Processes which overrun, are able to utilize any spare processor capacity in the system, including any additional unused processor capacity made available at run-time by process underruns, to maximize their chances of still meeting deadlines despite overrunning. With this method, process executions can migrate from one processor to another processor and can be preempted by other process executions at run time to provide greater flexibility in using available processor resources and meeting deadlines. The method increases both system utilization and robustness in the presence of inaccurate estimates of the worst-case computations of the real-time processes, while simultaneously satisfying important constraints and dependencies, such as offsets, release times, precedence relations, and exclusion relations.

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Daniele Costa, Massimo Callegari, Giacomo Palmieri, Matteo-Claudio Palpacelli and David Scaradozzi.

Bio-inspiration can lead to a significant improvement in propulsive efficiency and maneuverability of Autonomous Underwater Vehicles employed in large areas exploration. As a matter of fact, fish swimming capabilities are still far superior to what has been achieved by the modern nautical technology. In order to exploit the propulsive principles of fish swimming, a novel mechanism has been designed and prototyped to drive the thrust-generating caudal fin of the biomimetic underwater robot manufactured by the authors.

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Liu Haipeng, Gao Shiqiao and Jin Lei.

In recent years, the expansion of wireless sensors networks in our daily environment and the rapid development of low power consumption devices and MEMS devices have been driving research on energy harvester. In this paper, based on the analysis of electromechanical coupling characteristics of the PE-EM hybrid harvester, the equivalent vibration model and governing equation of hybrid harvester are established. And the output power expression of hybrid harvester is derived. The results of the theory analysis and experimental tests show that the harvesting performance of hybrid harvester is better than that of single harvest structure. The output power of hybrid harvester is larger and the bandwidth is wider than that of PE-only and EM-only harvest structure.

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Chenchen Sun, Guofang Gong, Fei Wang and Xiaoping Ouyang.

A hydro-viscous drive clutch is a complicated system with time-varying and nonlinear characteristics, a kind of adaptive PID control strategy based on single neuron algorithm is proposed, which can improve robust and self-adaptive of the system. Control performance comparisons with conventional PID control and fuzzy PID control are investigated on the hydro-viscous drive system. The theoretical analysis and the simulation results demonstrate the effectiveness of the proposed control strategy.

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Investigating the appliance of aluminium as a winding material with high efficiency electric motor 151

David Czegledi, Ferenc Szauter and István Lakatos.

Nowadays the driveline development of communal and individual transport is very significant. More and more hybrid and full electric urban vehicle can be found on city roads. The application of electric drive dominates in public transport as well. This tendency is shown in Europe, but it also can be observed in America and Asia. The figures show that the electric application tends to increase in the following years and decades.

Copper is solely usable as the winding material of full electric or hybrid driven vehicles. Based on predictions, the copper resources are running down, which means that the price of copper will greatly increase in a very short time, or these resources can be totally exhausted in an extreme situation. In this article, I investigate the applications of other metals, which could provide solutions to the replacement of copper.

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Tapio Heikkilä, Tadeusz Dobrowiecki and Lars Dalgaard.

The notion of the configurations and configurability is interpreted in the context of robotic and automation systems. A review is given on related methods and techniques, and how configurations relate to system and software life cycles. The modeling principles for configuration based design are outlined and proposal is made for a completely new way to reuse system model data by storing them as semantic descriptions in SW delivery packages, to be queried by system designers. A tentative design example is also presented.

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Jari M. Ahola, Tapio Heikkilä, Jukka Koskinen, Tuomas Seppälä and Tarmo Tamminen.

This paper presents a configurable CAD-based object recognition system for varying resolution 3D sensors such as Time-Of-Flight (ToF) cameras and laser scanners. The object recognition system is used for recognizing and localizing target objects on the basis of the geometric and topological information extracted from STEP-files. The novelty of our system is its configurability, i.e. its ability to adjust the level of detail of the database object models to the properties of the applied sensor system, e.g., resolution, accuracy and signal to noise ratio.

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Characteristics of the piezoelectric energy-harvesting from the torsional vibration of thin-walled cantilever beams 169

Shiqiao Gao, Guangyi Zhang, Lei Jin, Ping Li and Haipeng Liu.

In this paper, based on the torsion theory of thin-walled bar (or beam), the static and dynamic theoretical torsion models are established and its static and dynamic

characteristics and open voltage are analyzed for a piezoelectric energy-harvesting structure from torsional vibration. The results show that for this piezoelectric energy-harvesting structure with the thin-walled cantilever beam, the second modal frequency is 124.72Hz, the open circuit voltage can reach 1.82V when the excitation acceleration is 10m/s2. The torsion angle can reach 0.341° when the excitation acceleration is 3m/s with the second frequency.

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Implementation of a tracking system based on UWB technology in a retail environment 174

Marco Contigiani, Adriano Mancini, Primo Zingaretti and Rocco Pietrini.

This paper proposes a tracking system based on Ultra-wideband technology. The system provides the use of several Ultra-wideband antennas properly positioned inside a predetermined area and powered battery tags free to move inside the area. This system finds wide application in retail field. In fact, through the analysis of the collected tracking data, it allows to derive several information on the shoppers behavior inside the store. Behaviors that concern flows of walking, most visited areas inside the space dedicated to the shopping and average travel times.

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An integrated mobility system using real-time data for traffic simulation 180

Mirco Sturari, Ludovico Catani, Adriano Mancini and Emanuele Frontoni.

Traffic lights are very often equipped with cameras for smart disengagement of crossings. Surveillance cameras are placed in many key-points of the city's mobility for security purposes, such as neighbourhood entrances and parking areas. The idea of this study is to use this in place infrastructure, already installed and maintained by mobility stakeholders, without additional hardware costs. Combining these mobile and fixed sensors we created a Wireless Sensor Network and built on it a Geographic Information System (GIS) platform to manage and monitor urban mobility.
We extended this integrated system with an interface to Simulation of Urban MObility (SUMO), an open-source microscopic and continuous road traffic simulation package. Input files of simulator are generated by the system from real mobility data.

In this way our system manages and monitors urban mobility in real-time providing an useful instrument for planning the interventions mobility plans / infrastructures, being able to simulate the future state and further verify the effectiveness of what is realized.

Paper 54

An interoperable framework for domotic sensors network N/A

Giammarco Zagaglia, Emanuele Frontoni and Adriano Mancini.

The integration of device-level software provides a procedure according to the specifications of the sensor, which is often the same as other devices from other companies. For this reason a framework that allows to quickly develop new hardware and software complex systems, rapidly integrate new classes of devices in existing systems and control and centralize the data has been developed. This means that the framework allows to drastically reduce the integration time of the device at the software level in which networks of devices are used. This assumes to develop a System on Module to be used on all devices, develop a

library of integration to the framework at the firmware level and develop an interpreter command to run on this System on Module.
The part of the integration of new classes of devices is intended instead to add to the runtime framework each type of device described by an XML file, which will be immediately recognized, and to manage, configure and upgrade the device through the framework.

Finally, the section regarding the control and data centralization is intended to check data for statistical purposes, essential for understanding the market. A part of the framework deals therefore with the creation of statistical data for internal use to be able to create new development and improvement input.
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A cloud-based healthcare infrastructure for medical device integration: the bilirubinometer case study 186

Annalisa Cenci, Daniele Liciotti, Ilaria Ercoli, Primo Zingaretti and Virgilio Paolo Carnielli.

Medical devices, generally, have been unique units, so that a typical hospital room in an intensive care ward hosts a big number of stand-alone devices, each one with its own user interface.

Nowadays, these devices have some connection mechanisms, but the goal is to go beyond the simple connectivity that permits only the reading of the measured value on a computer monitor, to move towards a more complex device integration that offers the possibility to stream device data directly into patient electronic records, to create a database for further statistical investigations and to integrate the information derived from multiple medical devices into a single display.
In this paper, we propose a method to connect and integrate into a cloud-based infrastructure the bilirubinometer, which is a typical Neonatal Intensive Care Unit biomedical device that measures the amount of bilirubin in infants' blood, which is symptomatic of neonatal jaundice.

After data extraction process from the instrument, the database is normalised according to a record format defined in XML language. Then, through Web Services of importation, data is transferred to the cloud database.
It enables online sharing of encrypted healthcare data, reported in a standard language to allow a complete interoperability as well as a total security of shared data.
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Development of an automatic procedure to mechanically characterize soft tissue materials 192

Bernardo Innocenti, Pierre Lambert, Jean-Charles Larrieu, Silvia Pianigiani, Marina Paolanti, Michele Bernardini, Annalisa Cenci and Emanuele Frontoni.

In literature a standard protocol to develop an automatic procedure to mechanically characterize soft tissue material does not exist yet. In this paper we propose a

procedure that permits to automatically calculate the Young's modulus and the Poisson ratio for a soft material characterized during a uniaxial tensile test. The experimental setup requires the use of several markers and a camera for automatically obtaining the true stress strain curve of the soft material under test. In fact, in post processing the image analysis permits to automatically measure the real displacement of the material tracking the movement of the markers and the mean width variation of the specimen using a black and white threshold technique. Moreover, the algorithm through an automatic routine is able to linearize the true stress strain curve: the user can decide the number of linear segment desired and the regions of the stress strain curve in which to perform the linearization process. The procedure was initially tested and validated by using a known silicon material and later applied on a biologic material. The procedure was accurate, independent by eventual slipping of the specimen with respect to the tensile machine, and suitable not only for synthetic soft materials, but also for biological ones.

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Yang Li and Bo Chen.

This paper presents an integrated energy management strategy, which combines Rule-based control and Equivalent Consumption Minimization Strategy (Rule-ECMS), for a single shaft parallel HEV. The presented strategy is implemented in dSPACE real-time simulator and integrated with low-level powertrain component controllers. The performance of the Rule-ECMS strategy is compared with rule-based control for both Urban Dynamometer Driving Schedule (UDDS) and Highway Fuel Economy Test (HWFET) drive cycles.

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Eduardo Cuesta Montero, Alfonso Fernández-Manso and Carmen Quintano Pástor.

A new application of fractional calculus related to filtering and remote sensing is here shown. Since several inputs are commonly used to perform an accurate estimation of sensed areas, a fractional calculus based model allows to tune easily the filtering for every single input. In fact, the filtering is tuned by means of the viscosity parameters (order of fractional integrals) involved in the model. Numerical experiments fitting in the framework of remote sensing for coal mining area mapping will be shown.

Paper 61

A Low Frequency Piezoelectric Energy Harvester with Trapezoidal Cantilever Beam:Theory and Experiment N/A

Guangyi Zhang, Shiqiao Gao, Haipeng Liu and Xiaoya Zhou.

With the development of low power MEMS device and outdoor wireless sensor network, new energy supply has been a key to replace the traditional energy which has some disadvantages. We have found that obtaining energy from the daily low frequency vibration environment is a very efficient solution to ease the pressure of energy sources. In this paper, a utility low frequency piezoelectric energy harvester with trapezoidal cantilever beam is presented. And corresponding theoretical model, optimization method and comparison experiment are made. The results show that, the theoretical analysis results are in agreement with the experimental

results; under the condition of constant beam length, open- circuit voltage and output power of trapezoidal beam piezoelectric energy harvester are 81.6% and 167% more than those of the rectangular beam piezoelectric energy harvester, and output increases with the section change rate decreasing. In addition, In order to further broaden the frequency band and improve output characteristics, we use the nonlinear method to redesign the experiment based on the above experiments. The results show that distance and magnet polarity change have an important effect on output characteristics.

Paper 62

Influence of Vibration on the Performance of Tunnel Boring Machines 208

Xiaoyang Zou, Yongzhen Mi, Hui Zheng and Jianfeng Tao.

Vibration in a hard rock tunnel boring machine (TBM) during tunnel excavation has been thought to have significant influence on TBM performance, in particular its excavation efficiency. This paper presents a study on this issue. A dynamic model of TBM is established to derive its vibration response, considering not only both of cutterhead driving system and thrust system, but also the interaction between shield and tunnel invert which is modeled by a 3D Winkler foundation with uniformly distributed damping springs and sliders. Based on the obtained vibration response of an opening TBM under simulated rock breakage forces, the influence of vibration on critical performance of TBM, including energy efficiency of rock breakage, disc cutter wear rate and interaction between shield and tunnel invert, is investigated. The results show that energy efficiency of rock breakage decreases with increasing of kinetic energy and potential energy in TBM, especially with sharp rise of dissipated energy due to friction occurrence under large vibration circumstance. A large margin increment of disc cutter wear rate is brought about by TBM vibration. Different with the results in energy efficiency and disc cutter wear rate, strong vibration induced axial force between shield and tunnel invert could make the whole TBM pushed forward more easily than in static contact. This study provide a reference for comprehensive evaluation of vibration of a TBM and its rock-breaking.

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Robot-Assisted Ankle Rehabilitation for the Treatment of Drop Foot: A Case Study 214

Mingming Zhang, Shane Xie, Wei Meng, Guoli Zhu, Xiangfeng Zeng, Xiaolin Huang and Qun Xu.

This paper involves the use of an intrinsically-compliant ankle rehabilitation robot for the treatment of drop foot. The robot has a bio-inspired design by employing four Festo fluidic actuators that mimic skeletal muscles to actuate three rotational degrees of freedom (DOFs). A position controller in task space was developed to track the predefined trajectory of the end effector. The position tracking was achieved by the length tracking of each actuator in joint space by inverse kinematics. A stroke patient with drop foot participated in the trial as a case study to evaluate the potential of this robot for clinical applications. The patient gave positive feedback in using the ankle robot for the treatment of drop foot, although some limitations exist. The trajectory tracking showed satisfactory accuracy throughout the whole training with varying ranges of motion, with the root mean square deviation (RMSD) value being 0.0408 rad and the normalized root mean square deviation (NRMSD) value being 8.16%. To summarize, preliminary findings support the potential of the ankle rehabilitation robot for clinical applications.

Future work will investigate the effectiveness of the robot for treating drop foot on a large sample of subjects.

Paper 64

Modeling on stiffness of gripper in hardrock TBM 219

Wu Yajin, Tao Jianfeng and Liu Chengliang.

Grippers are matched to the excavated section and lie against the tunnel wall in the braced condition, which invariably subjected to the impulse loads. To reduce the TBM vibrations levels and improve the stability of gripper, this paper takes dynamic stiffness of gripper as research object, model and analysis are developed: firstly, using force equilibrium equations and flow continuity equation of gripper hydraulic system on different conditions, by linearization near the equilibrium point, expressions on dynamic nonlinear stiffness and static stiffness of gripper cylinder are obtained; secondly, combined with gripper - rock contact stiffness , proposed gripper TBM machine - liquid – rock (MLR) coupling stiffness; gripper stiffness can be controlled, consequently reducing the vibration levels of TBM .

Paper 65

Investigation of Serpentine Gait of a Snake Robot with a Wireless Camera 225

Chikit Au and Pinwei Jin.

In this article, the serpentine gait of a snake robot with a camera at its head is simulated and the stability of the camera view is investigated. It is found that the camera view stability is low due to the large swinging amplitude of the snake robot head during locomotion. In order to improve the view stability, an optimization approach is proposed to modify the relative angle between the snake robot head and its body. Finally, a snake robot with wireless camera is implemented to verify the effectiveness of the proposed approach.

Paper 66

Machine Vision Based Dual Channel Weld Seam Detection System for Aircraft T-joint Welds 231

Wenjun Shao, Yu Huang, Xiaolong Zhang and Gen Li.

Laser welding technology for skin-stringer joints in is widely used in aircraft manufacturing. Double-sided laser beam welding of skin–stringer joints is an approved method for producing defect-free welds. The main drawback for the use of single-sided welding method for T-joints is the occurrence of weld defects. In order to achieve dual-beam laser welded T-joint, a dual-beam laser welding platform based on multi-axis CNC machine is set up in this article. A novel control method of double-sided seam tracking and error compensation based on vision sensor is proposed. The result shows that the dual-beam laser welding system can achieve dynamic deviation compensation accurately in the double-sided welding process at a high speed.

Paper 68

A Tracked Mobile Robotic Lab for Monitoring Plants Volume and Health 237

Marco Bietresato, Giovanni Carabin, Daniela D'Auria, Raimondo Gallo, Gianluca Ristorto, Fabrizio Mazzetto, Renato Vidoni, Alessandro Gasparetto and Lorenzo Scalera.

Precision agriculture has been increasingly recognized for its potential ability to improve agricultural productivity, reduce production cost, and minimize damage to the environment.

In this work, the current stage of our research in developing a mobile platform equipped with different sensors for orchard monitoring and sensing is presented. In particular, the mobile platform is conceived to monitor and assess both the geometric and volumetric conditions as well as the health state of the canopy. To do so, different sensors have been integrated and efficient data-processing algorithms implemented for a reliable crop monitoring. Experimental tests have been performed allowing to obtain both a precise volume reconstruction of several plants and an NDVI mapping suitable for vegetation state evaluations.

Paper 69

How to use virtual prototyping to design Product-Service Systems 243

Margherita Peruzzini, Maura Mengoni and Damiano Raponi.

Numerous companies all around the world are shifting from traditional products to product-service solutions, thanks to the increased "intelligence" and " connectivity" of modern products and the more deep integration among mechanics, electronics, Information and Commutation Technologies (ICT) and Internet of Things (IoT). Such Product-Service Systems (PSSs) are usually designed and developed by considering product and service as separated entities with the consequent increase of design and validation difficulties. In addition, a final physical prototype has to be realized to validate the overall solution. In this context, Virtual Prototyping can support PSS design to reduce process iterations and time to market. However, actual virtual prototypes are usually conceived for product validation, and are not so effective for PSS. The paper defines a set of requirements for PSS simulation on digital models, and defines a set of tools for successful PSS prototyping.

Paper 70

Analysis, Design, and Control of a Novel Elastomeric Bearing Positioning Stage 249

Kuo-Shen Chen, Yen-Chu Teng and Yu-Cheng Chen.

As products are required with higher precision, vibration control becomes more important for precision machining and inspection. A stage with both fast positioning and relative vibration suppression can improve product quality. Elastomeric bearings are widely used in the seismic engineering and precision machine fields. By utilizing their stiffness anisotropy, miniaturized bearings can be made of rubbers and have the same functions as larger compliant mechanism–based designs. This provides possible advantages in precision positioning. In this paper, a single-degree-of-freedom precision stage containing four elastomeric bearings is designed and realized. The mechanical properties of elastomeric bearings are determined through essential material tests for modeling the system dynamics of the stage. The results show that the bearing stiffness is both frequency- and time-dependent and is modelled as as a generalized Maxwell model. A closed-loop control system comprising an AVM40-20 voice coil motor, an ASP-10-CTR capacitance probe, and an Integral Sliding Mode controller is used in associated with the stage. In comparison with a previous compliant mechanism–based design, the stage size is reduced from 130×40×15 mm3 to 30×33×33 mm3, the positioning stroke is increased from 101 μm to 139 μm, and the bandwidth is increased from 29 Hz to 350 Hz.

Paper 71

Wheeled delivery Robot Control System 255

Chuanjiang Li, Xingya Liu, Ziming Tom Qi, Ziqiang Zhang and Kaijun Bao.

With the continuous development of the catering industry, the demand for room service continues to increase, but with rising labor costs in China and many other factors, the human cost of room service have begun restricting the development of catering enterprises. In recent years, many robots are involved in room service, but their operations are not flexible and high cost. This paper presents an ultra-wideband and odometer fusion positioning technology to offer a delivery robot which can walk along a fixed orbit with flexibility and cost-effective.

Paper 73

Design and experiment of fiber current measuring system applied on TBM geological prediction 260

Xinxing Gao, Zhao Bin and Xu Ya.

In recent years, geological prediction based on induced polarization method has been developed because of TBM's wide application. The resistance of surrounding rock should be calculated by measuring the signal voltage and the current to evaluate tunnel's geologic condition. One problem of this method is that the resistance of front rock and side rock cannot be distinguished because TBM's cutterhead and shield are not insulated. A fiber current measuring system based on Faraday Effect and Ampere Circuital Theorem is designed and implemented to solve the above problem. The current to be measured is converted into linearly polarized light's angle in a fiber loop. With a polarizer and a photo electric detector, the change of the angle can be detected, which means the current passed through the fiber loop can be measured. When a fiber loop was placed on TBM's main drive bearing, the current flows toward cutterhead will pass through the fiber loop, others toward shield, their distribution ratio can be determined by the fiber current measuring system. In order to test system's features, we used a steel cylinder to simulate TBM's main drive bearing in laboratory, and the result shows that the fiber current measuring system has a good linearity and fit our needs.

Paper 74

The Vertical Adjustment System with Angle Closed Loop Control for TBM 264

Zuo Peng, Guofang Gong, Huayong Yang, Tong Liu, Zhen Zhang and Xiaoping Ouyang.

In this paper, a high precision vertical adjustment hydraulic system is designed to ensure the displacement control accuracy of the torque cylinders. The position relationship between the pitch angle and the torque cylinder in TBM vertical adjustment system is calculated, and it is linear with the torque cylinders displacement when the pitch angle is small. With the purpose of finding a synchronous control strategy ,the vertical adjustment with angle closed loop and the existing system were respectively established in AMEsim,The responses of the toqure cylinders displacement and the pitch angle to the step signal indicate that the displacement deviation of the left and right torque cylinder is reduced,and the pitch angle error is smaller.

Paper 75

A Nonliear Dynamics Model of TBM with Variable Contact Stiffnesses of the Grippers and the Hinges 270

Long Long Sun, Hai Dong Yu and Yong Zhao.

A lumped mass parameter model is established for the thrusting mechanical system of tunnel boring machines (TBM), in which the contact stiffness of TBM and surface of tunnel is considered. The nonlinear dynamics model is developed with the nonlinear contact behavior in the mechanical system and environment such as the interface of TBM and rock, and hinges and hydraulic cylinders based on the Newton-Euler equations. The natural frequencies and kinematic performance are discussed numerically. When TBMs excavate in the hard rocks, the effective thrusting forces decrease with the decrease of the angles between the cylinders and the mainbeam. The variable contact stiffness due to the complex geometrical structures has obviously influence on the dynamic performance, which should be considered in the precise prediction of the kinematic behavior.

Paper 76

Monitoring peripheral blood flow change using transmission photoplethysmography sensor 277

Musabbir Khan, Lachlan McKenzie, Alexander Amies, Christopher Pretty, Geoffrey Chase and Geoffrey Shaw.

Perfusion monitoring plays an important role in determining tissue oxygenation. This paper presents a non-invasive method to monitor peripheral blood flow changes, as an indicator for perfusion. A transmission mode finger sensor and a vascular Doppler ultrasound monitor were used to acquire photoplethysmograph (PPG) and blood velocity data. A series of vascular occlusion tests were conducted on 7 healthy human volunteers using a pressure cuff, to induce changes in peripheral blood flow conditions. The AC signal (PPGAC) amplitude was determined as an estimate for volumetric blood flow. Results shows PPGAC amplitude can detect changes in peripheral flow, with respect to the ultrasound Doppler. The two measurements showed good positive correlation (R2=0.705). However, this correlation may degrade with significant dynamic change in vessel diameter and/or at high blood flow conditions.

Paper 77

Development of Micromechanisms for Handling of Biomaterials under Laser Light 283

Ebubekir Avci and Guang-Zhong Yang.

Optical Tweezers are very useful systems to manipulate micro-scale objects in confined spaces. To prevent photo-damage of laser light on biological objects, indirect manipulation concept became appealing among researchers in the recent years. However, manipulation of a target object in a stable manner by using conventional microspheres as end effectors of Optical Tweezers is an arduous task as laser light does not trap only microspheres but also attracts target object itself. Moreover, with the indirect manipulation approach, rotation of the target object around horizontal axes (to turn it up-side down) is not feasible which is an important feature for some bio-applications. By using direct laser writing, we propose two seperate mechanisms to above-mentioned two problems of indirect manipulation approach. First, a microcarrier is designed for stable manipulation

purpose. Then, rotation mechanism is developed to extend rotational abilities of the Optical Tweezers. Both mechanisms are printed using Two Photon Photo-polymerization method. Furthermore, validation of proposed mechanisms are shown through optical manipulation experiments.

Paper 78

Application of Mirror-milling machining system to suppress vibration in thin plate work-piece 288

Jin Lan, Bin Lin, Shuai Yan and Ji-Xiong Fei.

To suppress the vibration in thin plate work-piece during machining process, a novel Mirror-milling system is presented in this paper. The mirror-milling machine system includes a mobilizabe supporting head which will periodically reposition in order to be able to improve stability of work-piece. In this paper, various numerical simulations are finished to analyze the effects of the support head's siffness, support points location and damping coefficient on vibration suppression. The simulation results indicate the mirror-milling system guarantees vibration suppression effectivaly.

Paper 79

Design and kinematic modeling of a planar piezo-actuated multistage compliant mechanism 294

Mingxiang Ling and Junyi Cao.

Multistage compliant mechanisms have been widely investigated in recent decades oweing to their multiplying displacement amplification and compact structure. This paper presents a new planar multistage compliant mechanism with no assembly errors, relatively high frequency response and large range. By defining an impedance factor to describe the hindering effect of the second layer on the preceding one, the combined displacement amplification ratio of the proposed multistage compliant mechanism is theoretically modeled based on the elastic beam theory and the principle of conservation of energy. Initial prototype is monolithically fabricated and experimentally tested. It exhibits a natural frequency of 987Hz and displacement of more than 260μm, which agrees well with the finite elemental results and the theoretical predictions. The accuracy of the proposed model and the vibration modal is also verified, which may be a versatile tool for designing.

Paper 80

A VUMAT of modified Mohr-Coulomb model and its application in TBM tunnelling simulation 299

Meidong Han, Zongxi Cai, Yitong Zhang, Chuanyong Qu and Kui Chen.

The modified Mohr-Coulomb model which combines conventional Mohr-Coulomb criterion with the maximal tensile stress criterion, can well describe the mechanical properties of rock. Based on the Fortran language, the modified Mohr-Coulomb model combined with a plastic damage law and composite failure criteria, is implemented in a finite element analysis package through the user subroutine VUMAT (vectorized user defined material subroutine). Numerical simulations of uniaxial tensile numerical test were performed to verify the precision and reliability of VUMAT. Then the dynamic process when TBM tunnelling through the composite rock was simulated with the user subroutine. Results show that the developed

VUMAT can well describe the mechanical behavior of the rock in the tunnelling process.

Paper 81

Self-Sensing at Low Sampling-To-Signal Frequency Ratio: an Improved Algorithm for Dielectric Elastomer Actuators 305

Gianluca Rizzello, Micah Hodgins, Stefan Seelecke and David Naso.

This paper presents a new self-sensing algorithm for Dielectric Elastomer actuators. The method allows to obtain accurate estimations of material capacitance and electrodes resistance from voltage and current measurements, by means of online identification algorithms, e.g., RLS. While the capacitance can be used to reconstruct the actuator displacement (self-sensing), the resistance can be used to extract further information on the actuator state, e.g., fatigue (self-monitoring). The new self-sensing method is presented and compared with a different algorithm previously developed by the authors. Simulations and experiments show how capacitance and resistance predicted by the new algorithm are in agreement with the values measured with an LCR meter. Moreover, it is shown how the accuracy of the new method does not deteriorate when reducing the sampling-to-signal frequency ratio (the method is tested up to a ratio of 2.5). This result enables achieving reliable self-sensing without a significant amount of online computation effort.

Paper 82

A Magnetic Force Induced Frequency-Up-Conversion Energy Harvesting System 311

Shun Chen, Li Ma, Tao Chen, Hui Cong Liu and Lining Sun.

This paper proposes a piezoelectric frequency-up-conversion (FUC) energy harvesting system induced non-contact magnetic force. The FUC system is composed of a lower frequency piezoelectric cantilever (LFPC) of 40Hz and a higher frequency piezoelectric cantilever (HFPC) of 85Hz. Both the LFPC and HFPC contain a magnetic proof mass at the end of the piezoelectric cantilevers. The experiment shows that the output power of the HFPC is 0.3 mW at 40 Hz and 1g, which is about three times higher than that of the LFPC. The FUC system is able to provide high energy conversion even at lower frequency vibration of less than 50Hz, which is more efficient compared to a conventional one.

Paper 83

Augmenting Pre-Silicon Simulation by embedding a Scripting Language in a SystemC Environment 316

Dominik Widhalm, Stefan Tauner and Martin Horauer.

Advancements in manufacturing technologies allow to integrate an ever increasing amount of functionality into single System on Chip devices (SoCs). This not only causes the well-known productivity gap, it also challenges the proper verification of these designs. While the efficiency of pre-silicon verification of purely digital designs is continuously increased, either by the use of sophisticated Hardware Verification Languages (HVLs) or with powerful software suites, there is a lack of applicable concepts for mixed-signal designs. Furthermore, pre- and post-silicon verification activities are still often treated separately preventing to exploit possible synergies. For these reasons there is a great need for new innovative mixed-signal

verification methods and flows that are able to cope with a soaring amount of functionality further aggravated by a shrinking time-to-market.

This paper presents an approach to use abstract test descriptions written in Perl (1) to increase the efficiency of the verification process of complex mixed-signal SoCs designs in a SystemC simulation environment and (2) to enable information exchange between pre- and post-silicon activities. Since Perl and SystemC are distinct languages several approaches to link them together were elaborated and are presented in this paper. Their suitability with respect to several key aspects is compared and their effectiveness for pre-silicon verification is evaluated on the basis of an example test case.

Paper 84

Research on the Experimental Test System of TBM Gripping-Thrusting-Regripping Mechanism 322

Kai Wang, Yuhu Yang and Zhaoguang Shen.

The gripping-thrusting-regripping mechanism is the core transmission part of Tunnel Boring Machine (TBM) to fulfill the excavation process in a circulative way. The performance of the mechanism exerts direct influence on the excavation efficiency, the excavation precision as well as the dynamic properties of the whole machine. Targeting at the problem that there are situations where the geological conditions are poor and the TBM is bearing huge impact loads and relevant experiment data are not available for the testing in the excavation site, this paper, based on the working conditions of TBM and similarity theory, intends to propose an experimental test system that simulates the tunneling work of TBM. This system can not only realize the simulation of tunneling work, but also, more importantly, simulate the changes of tunneling load and the physical characteristics variations of surrounding rocks. Therefore, the system can provide experimental support for the research of the load transmission pattern in the tunneling work of TBM, as well as the statics characteristics and dynamics characteristics of the mechanism.

Paper 85

3D Curvature Grinding Path Planning Based on Point Cloud Data 327

Guifang Zhang, Junwei Wang, Feng Cao, Yuan Li and Xiaoqi Chen.

This paper proposes a novel method which uses online measurement data to create robot path for 3D grinding of workpieces with complex surfaces. The surface is measured as point cloud by a 3D scanner. The point cloud data is processed by filtering and smoothing, and then used for path planning. The grinding paths are generated by creating a series of planes to intersect with the target surface. A point cloud data slicing algorithm based on octree is developed to calculate the intersecting lines between point cloud data and planes. Subsequently the equal step method developed discretizes the grinding path for smooth curvatures, and utilizes local plane fitting to estimate the normal at contact points.

Paper 86

Complementing Testing of IEC61499 Function Blocks with Model-Checking 333

Bernd Glatz, Fionn Cleary, Martin Horauer, Harald Schuster and Peter Balog.

IEC 61499 is a popular standard for distributed control systems. It uses a graphical, application-centric design approach by composition of function

blocks. After the design the system is usually partitioned and mapped to the available devices. The required communication between these devices is handled by the runtime and/or the target implementation and is, hence, transparent to the development process.

This paper proposes an approach that complements traditional testing of IEC 61499 function blocks with model-checking. To that end, an automated translation approach is presented that details the generation of models for the popular Uppaal model-checker. The usefulness of the taken approach is elaborated by investigating the test of a segment of a modern building automation system.

Paper 88

Electret-based electrostatic energy harvesting device with the MEMS technology 340

Yulong Zhang, Anxin Luo, Yixin Xu, Tianyang Wang, Ai Zhang and Fei Wang.

In this paper, we propose an electrostatic energy harvester with an out-of-the-plane gap closing scheme. Using advanced MEMS technology, two components of the energy harvesting device are fabricated from two silicon wafers. A spray coated CYTOP polymer is used both as an electrets material and an adhesive layer for low temperature wafer bonding. The overall size of the device is about 13 × 18 mm^2. With an external load resistance of 16 Mohm, a power output of 4.04 μW is achieved when vibration amplitude of 1g (~9.9 m/s2) is applied at the resonant frequency of 155.8 Hz. The frequency response of the device is characterized and broader bandwidth is observed at higher acceleration amplitude due to the squeezed air damping. The response on random vibrations is also tested. An average power output of 2.22 μW is harvested when vibration is applied at random frequency in a range of 160 ± 12.5 Hz with RMS acceleration of 10.5 m/s^2.

Paper 89

A New Automatic Program to Generate Parametric Model of Shield Cutter Head 346

Kui Chen, Meidong Han, Yanqun Wang, Zongxi Cai and Chuanyong Qu.

The key parameters for structural characteristics of shield tunnel machine's cutter head were selected based upon some typical structures used in the design of cutter heads. Then a new parametric model generation program of finite elements numerical model in ANSYS' APDL language was developed for the further analysis. The program can automatically generate a parametric finite elements model of shield cutter head to use in the analysis of the strength and stiffness of shield cutter head.

Paper 90

Human Gaze Commands Classification: A Shape Based Approach to Interfacing with Robots 352

Trevor Lynn Craig, Carl A. Nelson, Songpo Li and Xiaoli Zhang.

The sense of sight is one of the main outlets to how we interact with the world around us. Using eye tracking methods, this sensory input channel may also be used as an output channel to provide commands for robots to follow. These commands to the robot could then be used to assist severely mobility-limited individuals in the home or similar environments. This paper explores the use of visually drawn shapes as the input for robot commands. These commands were

recorded using low-cost gaze tracking hardware (Gazepoint GP3 Eye Tracker). The data were then processed using a custom algorithm in MATLAB to detect commands to be passed to a small humanoid robot (NAO). Using the techniques and procedures given in this paper, people with limited mobility will be able to input shape commands to have robots like NAO react as personal assistants. This is also extensible to gaze-based human-machine interfaces in general for a variety of applications.

Paper 91

Design And Testing Of A Novel, Low-cost, Low-voltage, Functional Electrical Stimulator 358

Ashley Stewart, Christopher Pretty and Xiao Qi Chen.

This paper presents the design of a novel, noninvasive, low cost (< $70), low voltage (< 46 V maximum output, 6.1 V power supply), functional electrical stimulation (FES) circuit aimed at upper-limb stroke rehabilitation. The novel component of the circuit is the unique topology. This circuit uses a boost converter in series with an H-bridge to produce the required biphasic pulses. The stimulator is controllable using a range of different microcontrollers. The low voltage used makes this circuit inherently safer than circuits which use much higher voltages, up to 500 V. The circuit has been successfully tested on the bicep muscles of one healthy subject and is capable of inducing flexion of the elbow with as little as 12 V.

Paper 92

Fuzzy Automatic Contrast Enhancement Based on Fuzzy C-Means Clustering in CIELAB Color Space 364

Po Ting Lin and Boting Rex Lin.

Some traditional methods for image contrast enhancement are based on histogram equalization, which however has the drawbacks of producing visual artifacts or excessive image strengthening due to improper settings of enhancement parameters or non-smooth color adjustments in different color spaces. A novel method of Fuzzy Automatic Contrast Enhancement (FACE) is presented in this paper. FACE first performs a fuzzy clustering method to segment an image while the pixels with similar colors in the CIELAB color space are classified into smaller image clusters with similar characteristics. The pixels in each group are then spread out away from the center of the belonging cluster in the RGB color space in order to enhance the image contrast but keeping the similarity of pixel colors in the same cluster. A universal contrast enhancement variable (UCEV) was defined and optimized to maximize the image randomness (i.e. entropy of the image) in order to automatically enhance the image contrast. A more uncongested distribution of the image pixels ensures a greater image contrast. The proposed entropy-maximization process is capable of improving the image quality without any human-defined control parameters. The fully automated image enhancement process intelligently clusters the pixels with similar color characteristics and is general for the contrast enhancement of images in various color distributions. Many images with different color distributions were tested and the results showed that FACE is capable of avoiding visual artifacts and excessive strengthening. Compared with the traditional histogram equalization method, the proposed method shows higher effectiveness in contrast enhancement and performs better in retaining the colors of the original images.

Paper 93

Tunnel Deformation Monitoring based on Laser Distance Measuring and Vision Assistant 374

Chuang Gan and Yong Lei.

Full Face Rock Tunnel Boring Machine (TBM) has been applied in many underground tunnel projects. During the operation, the safety of the TBM is one of the major concerns in the construction project. One of the major safety concerns is the deformation of the tunnel. Minor tunnel deformation may cause additional delay of the operation due to rock cleaning and equipment replacement, whilst major deformation may jam the TBM or even endanger personnel safety. Hence a tunnel deformation monitoring system is needed during the operation of the TBM to deal with the problem of lacking of adaptability to geological conditions. In this paper, a visual assisted tunnel deformation measurement system is presented to automatically measure the deformation of the tunnel by using marked targets on the surrounding rock of the tunnel. The system mainly consists of a camera, a laser displacement sensor and a Pan-Tilt. The targets is marked by fluorescent coating and extracted by threshold segmentation method. Target is aimed using window tracing. The three dimensional coordinate of target point is calculated by using the principal of polar coordinates. A experiment platform is set up to verify the feasibility of the system. The experiment results show that the error of relative distance between two targets is smaller than 2mm within measuring range. The system can provide a high precision automatic measurement of the TBM tunnel.

Paper 94

Kernel PCA and Mahalanobis Distance based Health Assessment Methodology for the Cutting Wheel of Mixshield Machine 380

Shuai Zhao, Yixiang Huang, Chengliang Liu, Lin Li and Jiyun Wang.

The performance of the cutting wheel system is critical to the mixshield machine in tunneling because to identify and fix the key faulty components may take days or weeks, or even be impossible in the middle of a tunnel. Thus, it is necessary to develop the prognostic system. In this study, we propose a prognostic method in order to evaluate and predict the health status of the cutting wheel, which is based on an integration of Kernel PCA and Mahalanobis Distance. In this methodology, a mapping relationship between the build-in sensor data from SCADA system and the cutting wheel performance is established. The features that are sensitive to the mixshield machine performance are extracted and mapped to the kernel principal component space. The health value of the cutting wheel performance in each ring is calculated by the Mahalanobis distance measurement. Compared with the traditional empirical methods in engineering, the results show that the proposed method is more accurate and has good real-time performance. The parameters related to the cutting wheel are available in the PLC interface of mixshield machine. Among many cutting wheel assessment technologies, this method assessment can only performed on the data from SCADA system without any extra sensors. So it can be embedded in the SCADA system and enable the online real-time assessment for the performance of cutting wheel of the shield machine.

Paper 95

Advanced geological detection instrument for TBM tunneling based on AC induced polarization method 386

Haojie Jian, Zicheng Li, Bin Zhao and Guoli Zhu.

Currently, there are some methods for geological prediction method in tunneling using tunnel boring machine (TBM). The Bore-tunnel Electrical Ahead Monitoring (BEAM) is popular in the advanced detection based on the current method of electrical prospecting. However, the drawbacks of BEAM in the cost and complexity limit the application for geological prediction. This paper proposes a novel detection instrument for advanced geological prediction based on the characteristics of BEAM system. The instrument is implemented by the hardware voltage parallel method, which can realize the high speed and high precision measurement of the geological apparent resistivity and dispersion rate in dynamic tunneling process. It selects several cutting head of TBM as the main electrodes, which are set at two kinds of electrode distribution modes. It can achieve good detection results by switching between electrode distribution modes and scanning modes which is available by the rotating of working face. Experiments have been carried out to test for TBM experiment model in the proposed instrument. The results of experiment verify the feasibility and effectiveness of the proposed detection instrument.

Paper 96

Tracking Performance of Pneumatic Artificial Muscle Actuator using Iterative Control Algorithm 391

Seung Guk Baek, Kyeong Ha Lee, Zheng Yuan Li and Ja Choon Koo.

A pneumatic artificial muscle (PAM) have been studied in several fields due to its flexible property. However, it has some troubles in tracking performance and control of a PAM because of the inherent flexibility in material and air. In this study, applicability of Iterative Control(IC) algorithm to a PAM was investigated so as to achieve improvement of tracking performance despite of large non-linearity of a PAM. For this, a PAM virtual simulator was constructed, and the IC algorithm was applied to it in open loop operations and closed-loop operations. Then assessment of these tracking performance was done with time histories and tracking error rms. It seems that the IC algorithm with a linear model is valid to improvement of tracking performance of a PAM, but it has a final convergence limit on account of the use of a linear model.

Paper 97

A Framework of Optimal Remote Sensing using Small Unmanned Aircraft Systems 397

Brandon Stark and Yangquan Chen.

The use of small Unmanned Aircraft Systems (UAS) for remote sensing applications have increased significantly over the past decade. However, effective and efficient data collection methods and strategies are still being developed. The use of an effective small UAS methodology has become necessary, but it has additionally become important to also examine optimal remote sensing with respect to data quality. In this paper, a framework for the optimization of collecting remote sensing aerial imagery with small UAS is presented. Compared to other remote sensing techniques, the use of small UAS introduces several new tunable parameters that may have significant impact on data quality and the resulting analysis. The framework presented is a conceptual structure that describes optimal remote sensing with regard to the spatial, spectral, and temporal factors that provide the greatest signal-to-noise ratio for the desired application or purpose. Each of these factors are introduced and discussed as they pertain to a variety of parameters enabled by small UAS.

Paper 98

Synchronization Control of Dual-drive System in Gantry-type Machine Tools Based on Disturbance Observer 403

Li Ping, Zhu Guo Li, Gong Shihua, Huang Yu and Yue Lan.

Precise synchronization motion control has always been a problem need to be solved in the gantry-type NC machine tools (GNCMT) with a dual-drive system. The complexity of the system puts forward a great challenge for the setting of the PID controller parameters. In addition, one of the key elements which seriously affects the synchronization precision of the dual-drive system is the disturbance. For the realization of precise synchronization control, a mathematical model of the dual-drive system which combined with the mechanical coupling dynamic model of gantry mechanism, the dynamic model of transmission system and the control structure with three closed-loops of each axis was presented firstly. And then, PID parameters of each axis was tuned based on Genetic Algorithm (GA). In order to reduce the effects of friction and eccentric load disturbance on the synchronization performance and improve the anti-interference of the system, a synchronization control strategy based on disturbance observer (DOB) which used the identified model as the nominal model was proposed. Finally, a simulation analysis was carried on. The simulation results showed that the synchronization performance of dual-drive system in GNCMT is obviously improved through the disturbance compensation using the DOB.

Paper 99

Design of Flow and Pressure Coupling Controller for Independent Metering Valves Control System 410

Bin Zhang, Shuang Wang, Yuting Liu, Qi Zhong and Huayong Yang.

Compared with traditional valves control system, independent metering valves control system (IMVCS) broke down the mechanical coupling of the meter-in and meter-out orifices so that it increased the control degrees of freedom. Usually two spools were used to determine one actuator's state. The key difficulty was coordinating the opening displacement to output pressure and flow according to control strategy. This paper introduced the components and working principle of IMVCS. A flow and pressure coupling controller was designed to control both velocity of piston and pressure in each chamber. A SYS/BIOS based embedded operating system was adopted for fast response. Large set of sensors can be integrated which their amplifying circuits were designed on board. The IMVCS used dual close loop control to monitor and modify pressure and flow in real-time. Four types of threads were provided to schedule tasks. The real-time multitasking control software was developed. To verify the control strategy and PCB'A, a preliminary experiment showed the results of step response and sine signal tracking that two spools worked by onboard controller.

Paper 101

Tracking control of nano manipulating systems: a parallel phase-optimal notch filter approach 415

Songsong Lu, Peng Yan and Zhen Zhang.

This paper proposes a trajectory tracking control structure combining a baseline robust controller and an optimal notch filter in order to achieve ultrahigh precision tracking. The baseline robust controller is developed through μ-synthesis for the

purpose of robust stability and servo performance. An optimal phase filter which contains the dynamic characteristics of reference signals, is introduced on top of the baseline robust controller with a parallel connection in order to improve the tracking performance without sacrificing the stability robustness of the closed-loop systems. The proposed control strategy is deployed on a customize-designed nano-manipulating system driven by piezoelectric actuators, where real time experiments demonstrate excellent tracking performance in the presence of high-frequency, multi-frequency and variable frequency periodical reference signals.

Paper 102

The effect of size scale parameters on the structural behavior of carbon nanotube based nano-actuator 420

Iswan Pradiptya and Hassen Ouakad.

In this work, the structural response of a carbon nanotube based nanoactuator under a parallel-plates electrostatic actuation is investigated assuming a strain gradient theory. The sixth-order partial differential equation governing the mode shapes and natural frequencies of beam using Euler–Bernoulli and strain gradient theories are derived. A Galerkin decomposition technique is utilized to convert the partial differential equation to ordinary differential equations representing the system mode shapes. The proposed approach is verified by comparing it to previously published works. The main advantage of the proposed technique based on the Galerkin method is its simplicity and also its low computational cost in analyzing the response of a carbon nanotube based actuator under the effect of initial curvature, size-dependent parameters, and any actuating loads. Additionally, the influences of the axial forces that may arise from any thermal effects were taken into consideration in the derived model. The results obtained based on strain gradient theory, are compared with the classical continuum theory. It is shown that the strain gradient theory leads to higher frequency in comparison with the classical one.

Paper 103

Indoor Localization of Mobile Robot with Visible Light Communication 426

Hamid Sharifi, Akshaya Kumar, Fakhrul Alam and Khalid Arif.

This paper focuses on the implementation of visible light communication (VLC) with an autonomous mobile robot to provide indoor localization. Recent research on VLC, mostly in the form of simulations, offers the opportunity to conduct real life experiments and test the theory. Accurate indoor positioning is achieved by employing multi-frequency method with received signal strength (RSS) to calculate the distance of the robot from each LED installed above the robot in a plane parallel to the plane of the robot base. Multi-frequency method consists of each LED transmitting its location ID at a different frequency. It is demonstrated that the receiver is able to separate each location ID from simultaneous data transmission with a bandpass filter.

Paper 104

Kinematic Analysis And Synthesis of a Novel Gripper for Dexterous Applications 432

Nahian Rahman, Luca Carbonari, Ferdinando Cannella, Matteo Palpacelli and Mariapaola D'imperio.

This paper demonstrates kinematic analysis and synthesis of a novel, modular, reconfigurable gripper, which is capable to manipulate plurality of object. The gripper consists of four identical modular fingers, dexterous among all axes. Each modular finger of the gripper is conceived to the aim of satisfying efficient grasping, manipulation and also object release with accordance of desired posture. The proposed gripper has 16 DOFs, which can be reduced by decreasing the number of fingers depending on its target uses. In this paper, the in-hand manipulation capability is explained from kinematic perspective and some analysis carried through to synthesize the gripper for user specific applications.

Paper 106

A supporting system of jacquard circular knitting machine for knitting design and manufacturing 438

Xin Ru, Laihu Peng, Weimin Shi, Yanhong Yuan and Xudong Hu.

A supporting system of jacquard circular knitting machine for knitting design and manufacturing has been designed in this paper. The system has two layers named knitting design layer and knitting manufacturing layer. The knitting design layer is a user interface to design knitting pattern and action by graphic pattern and editable order table. The knitting design layer is an interface between knitting design and electrical control system and circular knitting machine. The pattern subsystem provides specific drawing tools designed for knitting design. The action subsystem uses knitting process action instead a series of mechanical parts action. These make the knitting design easy and convenient. The knitting manufacturing encode designed pattern and action orders to data which can use for controlling circular knitting machine. This paper introduce how to analyze designed pattern and action. And the system check knitting process before encoding data. Data compression employed to save memory space. Test has proved, this supporting system perform well for jacquard circular knitting machine to design and manufacture knitting.

Paper 107

Flexible Robotic Arm Dynamics through Deflection Screw Approach 442

Mariapaola D'Imperio, Luca Carbonari, Myrel Alsayegh, Torsten Betram, Matteo Claudio Palpacelli, Darwin Caldwell and Ferdinando Cannella.

The design and control of robotic systems capable of performing dynamic tasks, such as those involving stable impact, is of growing interest within the robotic community. If their structure is conceived as rigid, it results in massive and bulky systems, so that high forces are generated in the interaction with the external environment. At the opposite, if the robotic structure is designed as flexible, the interaction with the external environment produces lower forces thanks to their weight reduction and to the energy absorption guaranteed by the structural deformations. However, adding flexibility leads to unwanted vibrations which is a major drawback, that must be taken into account by the control algorithm to prevent resonance phenomena and to guarantee precise task performance. In this paper, the authors propose a structural model of a flexible robotic arm to be implemented in a model based control algorithm. The study is based on the screw theory approach which allows for an easy-to-manipulate concise symbolic representation for both kinematics and dynamics.

Paper 108

Bio-inspired Multitasking Robotic Gripper Design and Development 448

Kamila Pillearachchige, Tanisha Pereira and Khalid Arif.

The purpose of this study is to develop a bird-like claw mechanism that allows amphibious motion for walking, swimming and grasping on land. The inspiration for this work came from birds, which are capable of moving on land and grasping objects, and able to navigate through water. The motion of the bird foot has not been studied in detail before hence there is an opportunity to advance work in this area, and design a bio-inspired mechanism. This paper demonstrates the viability of the use of the claw mechanism for grasping objects compared to the grasping capabilities of the human hand. This claw model has only half the number of joints of a human hand therefore offers lower cost and easier management. Its smaller palm size facilitates the handling of small items. A hardware scaled model of a bird foot is designed to show how simple manipulation tasks can be done.

Paper 109

TBM Cutterhead Structure Optimization Based on Sensitivity Analysis 453

Zhiyong Ji, Ben Guo, Yimin Xia and Lu Tang.

Cutterhead is one of the key parts of tunnel boring machine (TBM) with complex structure. It is subject to poor work condition, and has limited working space which results in great difficulty to examine and repair. Cutterhead design must consider key factors such as strength and rigidity. Improper structure design will cause excessive overall or local vibration damage of the cutterhead. In this paper, finite element simulation was adopted to analyze the sensitivity and effects of structure parameters have on static and dynamic performance of cutterhead. 5 structure parameters with high sensitivity were selected to establish a fuzzy optimization mathematical model targeting at optimizing strength and rigidity of cutterhead structure. The Multi-Objective Genetic Algorithm (MOGA) was adopted for goal-driven optimization analysis on cutterhead structure, and the cutterhead design parameters with optimal overall performance were obtained in decision space. The maximum von mises stress was reduced by 43.6% and the maximum strain was reduced by 12.6% after the design optimization.

Paper 110

Feature Extraction for Moving Object Detection in a Non-stationary Background 461

Kartikay Lal and Khalid Arif.

Classification of moving objects in a non-stationary background has become a vast area of study, which is used in various applications where neither the background nor the foreground is stationary. Feature detection becomes an important part to detect moving objects when the background itself is moving. Harris corner detection, SIFT (Scale Invariant Feature Transform) and SURF (Speeded-Up Robust Features) are three most commonly used feature detection algorithms. Clustering of feature points using block-based k-means clustering along with feature detection are used to distinguish moving objects from the background. This paper presents a comparative study among various methods that were evaluated and compared on performance, amount of points detected and computation time. The simulations were carried out in MATLAB.

Paper 113

Sensitivity analysis of a mini pointing device 467

Matteo Palpacelli, Giacomo Palmieri, Luca Carbonari and David Corinaldi.

The paper presents a preliminary study needed to carry out a kinematic calibration procedure for a mini pointing device. The latter inherits its kinematics from a conventional five-bar linkage. A sensitivity analysis of all the geometric parameters involved in the kinematic model of the device is performed within the device workspace. A model is proposed by assuming a non overconstrained kinematics for the machine. Such assumption allows to consider a coupled rotational and translational motion of its moving platform, that is usually designed to have a fixed center of rotation. Results show how the model can be simplified without a significant reduction of its position accuracy, at least in a significant region of the manipulator workspace.

Paper 114

Modular Robot Task Functionality Driven by Hybrid Automata 473

Kazi Mashfique Hossain, Carl A. Nelson, Prithviraj Dasgupta and José Baca.

Reconfigurability, self-reproduction and self-healing are unique behaviors found in the field of modular robotics. These tasks require docking or coupling and reorganizing of modules to form different configurations according to the task requirements. For successful task achievement, efficient information sharing between the modules, better perception of configuration and well-structured motion sequence or docking are very important. In a scenario where sharing resources between different configurations is a priority, it is crucial to have a well-defined, energy-efficient, task-specific and effective strategy of operation. This paper presents a method to (1) discover the topology of a given structure by a master module in a recursive manner, (2) share the information with another master module to compare the utility of current or future configurations and (3) make a successful docking attachment. These all use automata theory to minimize calculation overhead. The first two methods were tested in simulation for an arbitrary ModRED II (Modular Robot for Exploration and Discovery) configuration with nine modules that uses serial communication between modules, and the third was validated in hardware.

Paper 115

A Thruster Failure Tolerant Control Scheme for Underwater Vehicles 479

Lucio Ciabattoni, Antonio Fasano, Francesco Ferracuti, Alessandro Freddi, Sauro Longhi and Andrea Monteriù.

This paper extend our previous work [1] on the design of a thruster failure tolerant control scheme for under- water vehicles. The proposed control scheme is based on the use of a suitable thruster allocation algorithm, which consists on a modified version of the Moore-Penrose pseudo inverse. In this work, each thruster of the underwater vehicle can rotate, offering a significant advantage to optimize its control. When a thruster experiences a failure, the resulting thrust force, which should be allocated to the failed actuator, is reallocated to the still faultless thrusters. Moreover, the angle of each thrusters is fixed such that to minimize the control effort. A bank of controllers is built so that each controller is designed to control the considered underwater vehicle under a specific actuator failure

scenario. These are preliminary results and their simulations results will be reported in the final version of this work.

Paper 116

New dynamic model for a Ballbot system 485

Andrea Bonci.

A Ballbot is a self-balanced mobile robot designed for omnidirectional mobility. The structure self-balanced on a ball giving to the system only one contact point with the ground. In this paper the dynamical model of a Ballbot system is investigated in order to find a linearized model which is able to describe the three-dimensional dynamics of the mechatronic system by a simpler set of equations. Due to the system's complexity, the equations of motion are often obtained by the energy method of Lagrange, they consist of a vast nonlinear ordinary differential equations (ODE), which are often numerically linearized for small perturbations. The present paper proposes to model the whole 3D dynamics of the Ballbot with the Newton-Euler formalism and Tait-Bryan angles in order to describe the model in terms of the system's physical parameters without resorting to numeric solution. This physical modelling is introduced to allow the simplification of the dynamic motion control of the ballbot.

Paper 117

A motorcycle enhanced model for active safety devices in Intelligent Transport Systems 491

Andrea Bonci, Riccardo De Amicis, Sauro Longhi, Emanuele Lorenzoni and Giuseppe A. Scala.

This paper proposes to enhance an existing motorcycle dynamics model, in order to take account of the longitudinal dynamics, the wheels dynamics and the rear wheel traction. The added equations of motion are obtained using lagrangian formulation. Also, to model the road surface, two additional equations describing the longitudinal slip and the longitudinal forces dynamic are included. The model is able to describe the coupling of the in-plane (longitudinal) and out-of-plane (lateral) dynamics and represents a suitable computational tool for designing preventive motorcycle active safety systems and controller synthesis applications. Simulation results and discussions are given in order to illustrate the effectiveness of the proposed mathematical tool.

Paper 119

An advanced detection approach based on support vector machine during tunnelling 497

Chuncao Zhang, Guoli Zhu and Lan Yue.

A new tunnel advanced detection method is proposed using disc cutter of tunnel boring machine(TBM) as the center electrode with DC resistivity principle,and unfavorable geology ahead or side of tunnel face is predicted. The simulation of abnormal characteristics for electrical resistivity is discussed under different ground conditions. Then the classifier using support vector machine(SVM) algorithm is built to differentiate the position of abnormal geology body:in font or the side of tunnel face. The K-cross validation is used to choose the optimal parameters of SVM.The result indicates that the method can effectively and directly reflect the position of

anomaly in front of tunnel face and provide the reference for site geological prediction.

Paper 120

A Mobile Agent-based Coalition Formation System for Multi-Robot Systems 501

Binsen Qian and Harry Cheng.

This paper presents a bio-inspired mobile agent-based coalition formation system for recruiting modular robots into different teams. A mathematical model for the coalition formation problem is described in this article. A mobile agent-based system is presented to solve the problem described. The system aims at bridging the gap between theory and practice in robots coalition formation. With this system, it can recruit a large scale of robots into many different groups effectively and efficiently for a variety of applications, such as the parallel performance of multiple tasks by multiple teams of robots. Unlike the centralized system, each robot will make its decision based on the ant colony algorithm to guarantee the global coalition formation efficiency. Also, due to the benefits of the mobile agent technology, the system has a high flexibility to integrate and adopt various algorithms to meet different requirements of robot recruitment. An overall system architecture and implementation details are presented in the article, as well as a coalition formation example to show the properties of the system.

Paper 122

Size Optimization and Fatigue Study of Ti-6Al-4V Membranes for Long-term ICP Measurement 507

Nireekshan Sodavaram, Khalid Arif, David Budgett and Daniel McCormick.

Drift in capacitive membrane pressure sensors is a serious concern in the long-term intracranial pressure (ICP) measurements. The major cause of drift is attributed to mechanical fatigue of the flexible membrane, which deflects in response to the applied pressure. Optimization of the membrane parameters, particularly size, could help in improving the fatigue life and overall performance of the membrane pressure sensors. In this paper, Ti-6Al-4V, grade 5, solution treated and annealed, biocompatible membrane has been numerically modeled for obtaining the overall desired size. In addition, multiaxial critical plane high cycle fatigue model was incorporated into the design to compute fatigue usage factors and cycles to failure of the membrane. With a diameter of 100 μm, thickness of 4 μm, the optimized membrane exhibited a life of about 10 billion cycles to failure.

Paper 123

Simulating and Testing a Non-Contact Structural Health Monitoring System 513

Alexander Amies, Christopher Pretty, Geoffrey Rodgers and Geoffrey Chase.

Structural health monitoring (SHM) is a technique which enables the integrity of a physical structure to be analysed in a non-invasive manner, meaning that no structural disassembly needs to take place. In addition to being non-invasive, information gathered using this technique can be immediately available to engineers. This technique can be applied to a number of different types of structures, ranging from buildings, to bridges, to vehicles. The research discussed in this paper is focused on the development of a novel non-line of sight (NLOS)

radio frequency (RF) based technique for performing SHM. RF transceivers will be placed at fixed locations on a structure, and by analysing transmitted and reflected signals around the network, the displacements between the transceivers can be computed. These measurements allow for the calculation of interstorey drift ratios (IDRs), which characterise the significance of the movement of a structure resulting from an external force. These IDRs can be used to understand the stress on the system, from which the structure's integrity can be understood. The feasibility of such a technique has been investigated, and the potential signal processing methods to utilise RF in SHM have been evaluated. Frequency-modulated continuous wave (FMCW) radar has been identified as the most suitable method due to its distance resolution and short sampling period. It has also been used in similar applications, demonstrating that the technique is viable in this field. A prototype FMCW system has been developed, and is currently ready for initial testing.

Paper 124

Experimental Study on Using Visual Odometry for Navigation in Outdoor GPS-Denied Environments 519

Mostafa Sharifi, Xiaoqi Chen and Christopher Pretty.

This paper presents an experimental study on utilizing visual odometry (VO) for pose estimation of mobile robots in outdoor GPS-denied environments. The experiments have been done using two different stereo VO algorithms implemented in Robot Operating System (ROS). The results have been compared with ground truth and drift has been identified. Sensor integration has been successfully used to minimize the drift. Challenges and possible solutions have been presented for future research and development.

Paper 125

Iterative Learning Control for Human-Robot Collaborative Output Tracking 524

Jonathan Realmuto, Rahul Warrier and Santosh Devasia.

This article studies human-robot learning control for collaborative output-tracking tasks. We propose an algorithm to adaptively tune the frequency-dependent iteration gain and apply it to two cases: when the desired output is directly available to the robot and when the robot infers the desired output from human achieved output. Experiment results are presented to illustrate the application of the proposed approach to a human-robot collaborative output-tracking task. Results show that the error converges to less than the closed-loop robot tracking error, and that the approach can provide varying levels of robot assistance by selecting the desired human-robot collaboration level.

Paper 128

Cooperative Control of Multiple UAVs for Forest Fire Monitoring and Detection 530

Khaled A. Ghamry and Youmin Zhang.

This paper proposes using multiple cooperative unmanned aerial vehicles (UAVs) for forest monitoring, and fire detection and tracking its propagation. The proposed algorithm solves the problems of forest fire including three stages; search, confirmation and observation. During search stage, the UAVs team moves in a certain formation shape in a leader-follower approach, a distributed sliding mode

formation control is designed to keep the desired formation shape during this stage. Once fire is detected, all sensory data will be sent to the ground station. A new reference trajectory is calculated according to the fire spread model generating an elliptic fire perimeter. The team begins following the new fire trajectory, afterward the leader will send reconfiguration commands to followers. Therefore, a distributed reconfiguration controller is designed based on sliding mode control (SMC) converting the formation problem from 2-D Cartesian frame of reference to the Polar frame of reference. This algorithm is used for evenly distributing and tracking UAVs team for elliptical fire perimeter. The effectiveness of the proposed algorithm is demonstrated using a six degree-of-freedom (DOF) quadrotor dynamic model and simplified fire front model.

Paper 129

Novel Humanoid Dual-arm Grinding Robot 536

Feng Cao, Yuan Li, Guifang Zhang, Junwei Wang, Xiaoqi Chen and Yanzheng Zhao.

In this paper, a humanoid grinding robot with two 6-DOF manipulators is proposed. The robot is equipped with force/torque sensors and binocular vision cameras, through which the interaction between the robot and the environment can be recognized and serves as a feedback for adaptive grinding control. Kinematics of the dual-arm robot is analyzed. Simulation of a grinding movement is carried out in ADAMS, during which a propeller blade weighing 40 kilograms is moved following desired trajectories. Then joint torques of the two manipulators are obtained. This paper further proposes an architecture of position-force control of the dual-arm robot. The simulation results show that the dual-arm robot performs well in grinding.

Paper 131

Self-sensing contact detection in Piezo-stepper actuator 542

Sanidhya Naikwad, Ruben Vandervelden and Hassan Hosseinnia.

Piezo steppers or piezo-walk actuators are attractive primararily because of their high accuracy and long range of motion combined in a single actuator. They are commonly used devices for short stroke scanners where significant range of motion is desired with good displacement resolution. A major performance limiting factor in these actuators is that, during stepping, large disturbances and vibrations are induced due to hammering action of the clamp piezolegs leading to development of stepping errors. In order to reduce these stepping errors, a good control scheme needs to be developed to drive the clamp piezo legs. It is of great advantage to use the self sensing property of the piezolegs to get a feedback signal because it prevents design changes to the actuator and saves valuable space. In this research, the self-sensing property of the piezolegs is applied to detect contact. This paper presents a novel application of the self-sensing contact detection method and a successful implementation inside the piezo-stepper to detect contact of the piezolegs with the driving rod.

Paper 132

Model-Based Manufacturing Based on STEP AP242 548

Rivai Wardhani and Xun Xu.

Transition of product data model from 2 dimensions (2D) to 3 dimensions (3D) has significant impacts in the manufacturing processes. A 3D model as representation of the product could be explored as the main source throughout the product lifecycle and this enables smart manufacturing system. But in order to be used by all of downstream customers, it must be delivered in a neutral CAD format, especially STEP AP242. Presentation and representation information in STEP AP 242 can be considered to build a system of model-based manufacturing by handling an automatics process planning. A design process structure is proposed to handle sufficient information in design file as an input to a model based manufacturing system.

Paper 133

Improving the Extricating Performance of TBM Cutter-head Driving System with Hydro-viscous Clutch 553

Haibo Xie, Huasheng Gong, Liang Hu and Huayong Yang.

This paper presents a new cutter-head driving system of tunnel boring machine (TBM) with hydro-viscous clutch (HVC) applied in order to improve the extricating performance, and a kind of theoretical methodology is proposed to analyze the extricating performance of HVC. Firstly, the Navier-Stokes equations are reduced upon the characteristics of oil film within HVC and the dynamical mathematical models of cutter-head system in the process of extrication are established. Then an approximate iteration algorithm is adopted to solve the NS equations and the analytical expression of the HVC output torque is obtained. Therefore the real-time simulation for the extricating process is performed. The theoretical results are validated in an experimental rig containing one friction pair. It is confirmed that the theoretical methodology is valid for the good agreement between the theoretical and experimental results. The results reveal that the HVC can indeed improve extricating performance of TBM cutter-head especially in relieving rigid impact. Furthermore, this also provides a design idea for the rotating speed regulating system especially in large mechatronics equipment when the hydro-viscous clutch is applied.

Paper 134

Acetabular Cup Seating Impact Sensing for Press-Fit Acetabular Cup Fixation 560

Liqiong Tang, Juliahn Tennant, Alana Forster and Murali Reddy.

Total Hip Arthroplasty (THA) is an excellent and reliable pain relieving operation which improves the function and quality of life for patients disabled by osteoarthritis [1]. Non-cemented hemispherical acetabular cup implants are now popular and accepted by surgeons world-wide [2]. In surgery, the acetabular cup is impacted into the native acetabulum with a cup impactor and hand-held mallets. Surgeons rely on multiple impacts to achieve the satisfactory stability and fully seat the implant [3]. The impacts on cup impactors greatly affect the quality of the surgery. Quantifying the load-transfer at the bone-implant interface and the understanding of the distribution pattern [2] is essential to determine the optimal force range that can satisfactorily seat the hemispherical acetabular cup to achieve

mechanical stability without causing potential damage to surrounding tissue. This paper presents a novel acetabular cup seating impact capturing system that quantifies and records the dynamic impacts applied on an acetabular cup by surgeons using a cup impactor with different sized mallets. The system is an integrated mechatronics system. It consists of three modules: microcontroller-based sensing, wireless communication and PC-based data acquisition. The system is designed as an add-on unit to the cup impactor. Laboratory-based preliminary testing was performed on the system by surgeons using synthetic polyurethane left hemipelvis saw bones. Dynamic impacts applied on a non-cemented hemispherical acetabular cup were captured, recorded and wirelessly transferred to a computer in real time.

Paper 135

Discrete time internal model-based tracking of a class of a servo gantry system with frequency-varying references 566

Zhen Zhang, Xiaodong Yang, Han Chen and Peng Yan.

This paper presents a discrete time internal model-based tracking control for a class of nonlinear systems driven by frequency-varying references. It is shown that if the error-zeroing input is polynomial of exosystem state, a linear time-varying internal model can be utilized to generate higher order modes of the exosystem. The proposed control design is applied to a high precision servo gantry system to track frequency-varying references. A numerous experiments are conducted to demonstrate the significant improvement of the tracking performance with higher order internal model.

Paper 136

ChDuino: A Real-time Controller for Arduino 572

Binsen Qian and Harry H. Cheng.

ChDuino is a cross-platform GUI based tool for managing Arduino boards and controlling them with connected USB cable or wirelessly through Bluetooth communication. The primary purpose of this software is to simplify the procedure of learning embedded systems so that people from various areas and K-12 students can also learn the concepts of microcontrollers. This paper presents the design and mechanism of ChDuino for real-time controlling Arduino boards. ChDuino supports multiple ways to communicate with a board, through USB or Bluetooth. It detects Arduino boards automatically with which libcharduino allows users to program an Arduino board in Ch without tedious compilation and other low-level technical issues.

Paper 138

CPSKit: A Low-Cost Reconfigurable and 3D-Printable Robotics Kit for Education and Research on Cyber-Physical Systems 578

Nathan Wong and Harry Cheng.

A new robotics kit for education and research on cyber-physical systems is proposed. Mechanical design, electrical design, and software development methods are discussed. The result of the design effort is the CPSKit, a 3D-printable Arduino-based mobile robot kit with various capabilities. The CPSKit is meant to be low-cost, 3D-printable, and use off-the-shelf electronics so the users can modify and build customized robots depending on their budget. The kit can be used at K-12 or

university levels, and the 3D-printable design makes it accessible for students to manufacture in the classroom using low-cost 3D printers. Moreover, the kit does not sacrifice key capabilities of a mobile robot, namely odometry and wireless communication. These capabilities which are necessary for a high-level autonomous mobile robot are often left out of existing educational robotics kits. Several applications and examples are demonstrated to show the capabilities of the CPSKit.

Paper 139

Control Strategies for Human-inspired Robotic Exoskeleton (HuREx) Gait Trainer 584

Jinghui Cao, Kazuto Kora, Andrew McDaid and Shengquan Xie.

A Human-inspired Robotic Exoskeleton (HuREx) gait trainer which utilizes an antagonistic pair of pneumatic muscle actuators (PMAs) has been developed. An accurate and robust control system with high bandwidth is needed to enable clinical testing of the HuREx on patients. This paper presents two papers implemented on the redeveloped robotic platform. One is an impedance based controller. The other is a robust sliding mode controller. Trajectory tracking tests with SMC showed faster tracking performance with good accuracy compared to the impedance based controller. Robustness of the SMC is also investigated with deliberately introduced modelling inaccuracy, through perturbations in the model parameters. This is used to show that the system can react when there are uncertainties in the real system, such as when a real patient is wearing the device. The contribution of this research is to demonstrate that a robust SMC can accurately and robustly control the HuREx device in the range required for gait rehabilitation.

Paper 140

Improved Multi-faults diagnosis for CNC Machine Tools 590

Bo Sheng, Chao Deng, Yuanhang Wang and Shengquan Xie.

According to the complex characteristics of multi-faults diagnosis for computer numerical control (CNC) machine tools, graph theory method has been researched. Mapping graph for multi-faults has been built and processed by the matrix algorithms and hierarchy algorithms. The improved failure mode and effect analysis (FMEA) based on the grey correlation theory has been used to improve the accuracy of fault locations. The results are sorted to determine the priority of potential faults. In this paper, graph theory method and the improved FMEA have been tested by using the example of ram feed system of CNC boring machine tools FB260.

Paper 142

Analyzing Heart Rate Variability Using a Photoplethysmographic Signal Measuring System 596

Yi-Feng Chen, Wan-Ting Chiang, Jiann-Shing Shieh, Maysam Abbod, Shou-Zen Fan and Quan Liu.

A heart rate variability (HRV) measuring system and its analysis method have been developed in this study. It is composed of a hardware measuring system based on a noninvasive photoplethysmographic (PPG) signal measuring device to acquire oxyhemoglobin saturation using pulse oximetry (SpO2) signals and a further software package including the methods used to filter and analyze the signals for

heart rate variability. Firstly, an experiment is designed for measuring heartbeat using the system to observe whether the empirical mode decomposition(EMD) can really inhibit noise or not on one volunteer with 10 minutes repeated for 10 times. Then, the hardware system and analysis method are tested on another 10 volunteers before and after receiving cold face immersion. The results of the first experiment have no significant difference with commercial instrument ($p > 0.05$), but the results using EMD perform better when signals are contaminated by artifacts. The second part experiment is subdivided into two stages. The results show that HR values at each stage have no significant difference with commercial instrument ($p > 0.05$). The LF significantly decreases from 0.33 0.03 to 0.31 0.03, while HF significantly increases from 0.41 0.07 to 0.43 0.07 indicating cold face immersion can increase parasympathetic and decrease sympathetic actions. Hence, LF/HF changes significantly from high (0.85 0.17) to low (0.74 0.17) before and after adding stimulation. Due to the reasons above, it confirms that the developed system can measure heartbeat and observe the heart rate variability. So the findings of this research may be useful for developing a home-made system to continuously measure HR and HRV for the purpose of convenience, portability, and operability.