

PROCEEDINGS OF SPIE

***Second International  
Conference on Testing Technology  
and Automation Engineering  
(TTAE 2022)***

**Yang Yue**  
*Editor*

**26–28 August 2022**  
**Changchun, China**

*Organized by*  
Key Laboratory of Conveyance and Equipment of Ministry of Education, East China Jiaotong University (China)

*Sponsored by*  
AEIC Academic Exchange Information Center (China)

*Published by*  
SPIE

**Volume 12457**

Proceedings of SPIE 0277-786X, V. 12457

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

Second Intl. Conference on Testing Technology and Automation Engineering (TTAE 2022),  
edited by Yang Yue, Proc. of SPIE Vol. TT100, TT10000  
© 2022 SPIE · 0277-786X · doi: 10.1117/12.2663703

Proc. of SPIE Vol. TT100 1245701-1

The papers in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. Additional papers and presentation recordings may be available online in the SPIE Digital Library at [SPIDigitalLibrary.org](http://SPIDigitalLibrary.org).

The papers reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from these proceedings:

Author(s), "Title of Paper," in *Second International Conference on Testing Technology and Automation Engineering (TTAE 2022)*, edited by Yang Yue, Proc. of SPIE 12457, Seven-digit Article CID Number (DD/MM/YYYY); (DOI URL).

ISSN: 0277-786X  
ISSN: 1996-756X (electronic)

ISBN: 9781510660199  
ISBN: 9781510660205 (electronic)

Published by

**SPIE**

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time)

[SPIE.org](http://SPIE.org)

Copyright © 2022 Society of Photo-Optical Instrumentation Engineers (SPIE).

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of fees. To obtain permission to use and share articles in this volume, visit Copyright Clearance Center at [copyright.com](http://copyright.com). Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher.

Printed in the United States of America by Curran Associates, Inc., under license from SPIE.

Publication of record for individual papers is online in the SPIE Digital Library.

**SPIE. DIGITAL LIBRARY**

[SPIDigitalLibrary.org](http://SPIDigitalLibrary.org)

---

**Paper Numbering:** A unique citation identifier (CID) number is assigned to each article in the Proceedings of SPIE at the time of publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online and print versions of the publication. SPIE uses a seven-digit CID article numbering system structured as follows:

- The first five digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc. The CID Number appears on each page of the manuscript.

# Contents

viii *Conference Committee*

---

## ONLINE TESTING AND PHOTOELECTRONIC DETECTION TECHNOLOGY

---

- 12457 02 **Analysis and research of laser measuring system in indoor large length standard device**  
[12457-14]
- 12457 03 **Research on information security testing technology of relay protection equipment** [12457-11]
- 12457 04 **Evaluation of the detection methods of oil pipeline leakage** [12457-4]
- 12457 05 **Introduction on test method and test result analysis of metal maintenance parts used for automotive aftermarket** [12457-8]
- 12457 06 **Application of isotope tracer technology in oilfield logging** [12457-78]
- 12457 07 **Source analysis of water invasion in bedrock gas reservoirs in Norther Qaidam Basin** [12457-16]
- 12457 08 **Development of comprehensive test bench for passive hydraulic brake caliper for subway**  
[12457-12]
- 12457 09 **Comparative analysis of TOFD detection technology and phased array detection technology**  
[12457-15]
- 12457 0A **Static load test analysis of escalator step based on different materials** [12457-25]
- 12457 0B **A new type of capacitive liquid level parameter measuring instrument for flotation pulp**  
[12457-2]
- 12457 0C **Automatic detection technology of water invasion in bedrock gas reservoirs in northern Qaidam Basin** [12457-77]
- 12457 0D **Research on plane defect detection technology of optical communication devices based on machine vision** [12457-51]
- 12457 0E **Application research of railway engineering survey based on BDS CORS** [12457-19]
- 12457 0F **Research on charging load prediction technology of electric vehicles based on multilayer perceptron** [12457-60]
- 12457 0G **Remeasurement method of power engineering pipe position based on tilt photography 3D reconstruction technology** [12457-27]

- 12457 OH     **Application of ultrasonic testing method in axial force testing of high-strength bolts** [12457-49]
- 12457 OI     **Error derivation of axis visualization in artillery direction accuracy test** [12457-37]
- 12457 OJ     **Analysis on the influences of probe parameters errors on measurement results in ultrasonic shear wave testing** [12457-18]
- 12457 OK     **GO-PdNi composite nanozyme for detection of ascorbic acid** [12457-54]
- 12457 OL     **Research on internal inspection method for  $\Phi$ 168 small-diameter pipeline** [12457-30]
- 12457 OM     **Research and application of automatic mineralogical detection of geological prospecting core section** [12457-48]
- 12457 ON     **Uncertainty analysis of inspection and testing equipment in special equipment testing** [12457-46]
- 12457 OO     **Nondestructive testing of the airfield pavement structural condition based on the GPR and HWD** [12457-31]

---

**AUTOMATION CONTROL AND SYSTEM EVALUATION OPTIMIZATION**

---

- 12457 OP     **Development of high speed fiber Bragg grating demodulator based on scanning laser source** [12457-75]
- 12457 OQ     **Design of distributed communication system for rainproof and crash proof electric vehicle charger** [12457-26]
- 12457 OR     **Analysis on the characteristics, advantages and development trend of mechanical design, manufacture, and automation** [12457-10]
- 12457 OS     **Research on low damage apple picking end-effector** [12457-79]
- 12457 OT     **Power distribution equipment maintenance strategy optimization considering maintenance-risk and failure-risk** [12457-68]
- 12457 OU     **Technical condition evaluation system for hydraulic device of heavy vehicle** [12457-63]
- 12457 OV     **Study on force calibration technology of cement mortar strength flexural and compressive testing machine** [12457-17]
- 12457 OW     **Tunnel punching inclination correction method based on three-laser rangefinder** [12457-76]
- 12457 OX     **Research on the relationship between testing system parameters and the signal strength of defect quantitative detection** [12457-56]
- 12457 OY     **Design of bridge gap detection and processing circuit based on grating sensor** [12457-50]

- 12457 0Z **Study on grading evaluation of moisture content in subgrade bed of high-speed railway based on ground penetrating radar technology** [12457-36]
- 12457 10 **Difference and comparison between NB/T 47013.2-2015 and DL/T 821-2017 in the radiographic nondestructive testing of power plant boiler** [12457-39]
- 12457 11 **A calibration method of demodulation loss for HDR** [12457-1]
- 12457 12 **Development and application of constant pressure water mixing control device for oil field gathering and transportation system** [12457-29]
- 12457 13 **Research on maintenance decision of ERS steel deck pavement system of Jiashao bridge** [12457-42]
- 12457 14 **Propagating phenomena of laser-generated surface acoustic waves interacting with cracks in bracket structure using finite element method** [12457-53]
- 12457 15 **Research on potential energy recovery technology of automated equipment in stereoscopic warehouse** [12457-45]
- 12457 16 **Vibration analysis for straddle-type monorail vehicle** [12457-40]
- 12457 17 **Multimodal motion analysis in the finger exoskeleton rehabilitation exercise** [12457-73]
- 12457 18 **Design, analysis and verification of forefinger exoskeleton movement mechanism** [12457-70]
- 12457 19 **Implementation and experimental validation of underwater measurement and positioning technology based on small transponder acoustic beacons** [12457-38]
- 12457 1A **Apple shockproof net cover automatic set machine design** [12457-71]
- 12457 1B **Numerical simulation of air distribution in the consultation room of patients with novel coronavirus** [12457-3]
- 12457 1C **Research on direct-drive permanent-magnet bogie for metro vehicles** [12457-35]
- 12457 1D **In-service inspection method and application of structural integrity of tank bottom** [12457-23]
- 12457 1E **Design of a fast sorting ball tennis device based on visual recognition and positioning** [12457-58]

---

#### INTELLIGENT INSTRUMENT MONITORING AND ALGORITHM MODELING

---

- 12457 1F **Automotive cyber security test method for UN-R 155 regulation** [12457-9]
- 12457 1G **Research on intelligent inspection of elevator** [12457-7]

- 12457 1H **Design of intelligent blind guide device based on image learning and positioning** [12457-72]
- 12457 1I **Monitoring vertical variation characteristics of atmospheric particulates under different weather conditions using unmanned aerial vehicle** [12457-13]
- 12457 1J **Identification of milk powder brands by visible-near infrared spectroscopy based on principal component analysis and neural networks** [12457-66]
- 12457 1K **Evaluation of the uncertainty of measuring semi-volatile organic compounds (SVOCs) in the flexible hose immersion solution by solid-phase extraction/gas chromatography-mass spectrometry (GC-MS)** [12457-24]
- 12457 1L **PID control of lower limb exoskeleton optimized based on genetic algorithm** [12457-69]
- 12457 1M **Research on defect detection algorithm of photovoltaic modules based on improved Yolov5** [12457-44]
- 12457 1N **Explosion-proof instrument monitoring and identification system based on OTSU** [12457-52]
- 12457 1O **Design of an industrial IoT-based tungsten oxide rotary furnace monitoring system** [12457-22]
- 12457 1P **Quantitative analysis of the effect of the damp heat test on optical imaging system under different scene usage conditions** [12457-32]
- 12457 1Q **Terrain telemetry method of power grid project based on RTK carrier phase difference** [12457-34]
- 12457 1R **Influence of different environmental aging tests on image quality attenuation of optical imaging system** [12457-33]
- 12457 1S **Automatic inspection technology for assembly compliance of satellite honeycomb sandwich panel based on machine vision** [12457-65]
- 12457 1T **A method for estimating the healthy operation state of 110kV power grid transformers based on key characteristic quantities** [12457-28]
- 12457 1U **Research on dynamic monitoring technology for overall lifting of steel corridor** [12457-47]
- 12457 1V **Study on energy system planning of wastewater reuse based on improved particle swarm optimization** [12457-55]
- 12457 1W **Artificial intelligence sink design for catering institutions** [12457-62]
- 12457 1X **Research on early warning of hydropower engineering construction safety accident based on SVM model** [12457-57]
- 12457 1Y **A brief discussion on the method of maintenance impact assessment in aviation deviation disposal** [12457-59]

12457 1Z **Shoulder rehabilitation training exoskeleton design for stroke patients** [12457-67]

# Conference Committee

## *Conference Chair*

**P. C. Srinivasa Rao**, Koneru Lakshmaiah University (China)

## *Publication Chair*

**Jude Hemanth**, Karunya University (India)

## Technical Program Committee Chair

**Yang Yue**, Xi'an Jiaotong University (China)

## Technical Program Committee

**Quanxin Zhu**, Hunan University (China)

**Alian Priou**, Université Paris Nanterre (France)

**Manuela-Roxanna Dijmarescu**, Politehnica University of Bucharest (Romania)

**Yajun Liu**, South China University of Technology (China)

**Yuliang Liu**, Zhejiang Ocean University (China)

**Fangfang Jian**, Henan University of Science and Technology (China)

**Sandip Kumar**, Aditya Engineering College (India)

**Sahil Verma**, Lovely Professional University (India)

**Ghous Bakhsh**, NED University (Pakistan)

**Ankit Sharma**, Chitkara University (India)

**Sivakumar Dhar Malingam**, Universiti Teknikal Malaysia (Malaysia)

**Yong Hao**, East Chinajiaotong University (China)