The 6th IFToMM International Symposium on Robotics and Mechatronics (ISRM 2019)

28-30 October 2019, Taipei, Taiwan
WELCOME MESSAGE

It is a pleasure to welcome everybody to Taipei, Taiwan for the 2019 IFToMM International Symposium on Robotics and Mechatronics (ISRM 2019).

ISRM is an event organized by the Technical Committee for Robotics and Mechatronics under the International Federation for the Promotion of Mechanism and Machine Science (IFToMM). The aim of ISRM is to promote timely scholarly exchange for the robotics and mechatronics R&D community. ISRM 2019 is the sixth edition of its series following the previous versions held in Hanoi, Vietnam in 2009, Shanghai, China in 2011, Singapore in 2013, Poitiers, France in 2015, and Sydney, Australia in 2017. The sixth ISRM comes to Taipei, Taiwan, hosted by National Taiwan University of Science and Technology during 28-30 October 2019.

Based on a peer-reviewed evaluation, The ISRM 2019 proceedings present state-of-the-art research findings in robotics and mechatronics in the 46 papers by the authors from 19 different countries throughout 5 continents. The contributed articles are categorised into 8 different technical sessions to be presented at the symposium, including Mechanism Synthesis, Analysis, and Design, Kinematics and Dynamics of Multibody Systems, Modelling and Simulation, Sensors and Actuators, Novel Robotic Systems, Industrial and Service Related Robotics and Mechatronics, Advances in Medical Robotics, and Historical Development in Robotics and Mechatronics. In addition to the contributed technical sessions, we are gratitude to host four keynote speeches offered by Professor Clément Gosselin from Université Laval, Canada, Professor Just Herder from Delft University of Technology, The Netherlands, Professor Marco Ceccarelli from University of Roma Tor Vergata, Italy, and Professor Jen-Yuan (James) Chang from National Tsing Hua University, Taiwan. An industrial session organized by MSC Software Taiwan is specially arranged to demonstrate the latest development and applications of multibody dynamics software.

The organizers would like to thank members of the International Scientific Committee of ISRM, the Program Committee, the Best Paper Awards Committee, and the Local Organizing Committee for their efforts in organizing the symposium, and the authors in addressing the comments and suggestions of the reviewers in their final submissions. The financial supports received from IFToMM, Ministry of Science and Technology Taiwan, Ministry of Economic Affairs Taiwan, Taipei City Government, and National Taiwan University of Science and Technology are acknowledged. The strong support of the Program Chair, Professor Terence Essomba, the Publication Chair, Professor Gun-Chen Chen, and the Best Paper Awards Chair, Professor Burkhard Corves, are also much appreciated. Finally, the editorial assistance from Springer for the conference proceedings is indebted.
ACKNOWLEDGEMENT

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GENERAL INFORMATION

Conference Venue
2nd floor, International Building (IB)
National Taiwan University of Science and Technology
43, Sec. 4, Keelung Rd., Taipei 106, Taiwan

Conference Website
http://www.isrm2019.org

WiFi
Free WiFi is available in the campus. Please ask your personalized login account/password at the Information Desk.

ISRM 2019 e-Proceedings
The PDF e-proceedings can be downloaded at the ISRM 2019 website (Homepage > News). The downloadable link is valid from 21 October 2019 to 15 November 2019.

Welcome Reception

Date: Monday 28 October
Time: 18:00-20:30
Gathering in front of the main entrance of IB Building at 17:45. Then a 5-min walk to the venue.

Venue: Living One Restaurant (LivingOne 台大明達館)
Address: The cross of Zhangxing St. and Sec. 3, Keelung Rd., Taipei (inside the National Taiwan University campus)

Banquet

Date: Tuesday 29 October
Time: 18:00-21:00

Venue: Silks Palace at National Palace Museum (故宮晶華)
Address: No. 221, Sec. 2, Zhi Shan Rd., Shilin District, Taipei

The return shuttle buses will depart at 21:00
Shuttle bus 1: To Taipei Main Station (台北車站)
Shuttle bus 2: To MRT Gongguan Station (捷運公館站) and Taiwan Tech

Registration
The registration desk is at the 2nd floor of the IB Building. It is opened daily during the conference dates.

Link to ISRM2019 official website
The numbers indicated in the timetable are the paper ID of the technical presentation.
KEYNOTE SPEECH 1
On the Development of Redundant Parallel Mechanisms for Physical Human-Robot Interaction

Clément Gosselin
Professor and Canada Research Chair in Robotics and Mechatronics
Laboratoire de robotique
Département de génie mécanique
Université Laval, Canada

Abstract
Physical human-robot interaction (pHRI) aims at taking advantage of the complementary capabilities of robots and humans. One of the key challenges in pHRI is to provide a high-bandwidth interaction that is safe and intuitive for the human user. To this end, it is proposed in this work to use low-impedance backdrivable redundant parallel robots. In the proposed designs, kinematic redundancy is used to increase the rotational workspace of parallel mechanisms, by alleviating the singularities. Architectures of redundant parallel and hybrid mechanisms are described and their kinematics is presented. Also, algorithms are devised for the avoidance of singularities. Prototypes of such mechanisms are introduced and the application to pHRI is highlighted. Solutions based on passive or active interfaces are proposed and examples of implementations are demonstrated.

Biography
Clément Gosselin received the B. Eng. degree in Mechanical Engineering from the Université de Sherbrooke, Québec, Canada, in 1985, and the Ph.D. degree from McGill University, Montréal, Québec, Canada in 1988. He was then a post-doctoral fellow at INRIA in Sophia-Antipolis, France in 1988-89. In 1989 he was appointed by the Department of Mechanical Engineering at Université Laval, Québec where he is a Full Professor since 1997. He is currently holding a Canada Research Chair in Robotics and Mechatronics since January 2001. He was a visiting researcher at the RWTH in Aachen, Germany in 1995, at the University of Victoria, Canada in 1996 and at the IRCyN in Nantes, France in 1999.

His research interests are kinematics, dynamics and control of robotic mechanical systems with a particular emphasis on the mechanics of grasping, the kinematics and dynamics of parallel manipulators and the development of human-friendly robots. His work in the aforementioned areas has been the subject of numerous publications in international journals and conferences as well as of several patents and two books. He has been directing many research initiatives, including collaborations with several Canadian and foreign high-technology companies and he has trained more than 120 graduate students. He is an Associate Editor of the IEEE Robotics and Automation Letters and of the ASME Journal of Mechanisms and Robotics.

Dr. Gosselin received several awards including the ASME DED Mechanisms and Robotics Committee Award in 2008 and the ASME Machine Design Award in 2013. He was appointed Officer of the Order of Canada in 2010 for contributions to research in parallel mechanisms and underactuated systems. He is a fellow of the ASME, of the IEEE and of the Royal Society of Canada.

KEYNOTE SPEECH 2
Spatially Curved Compliant Mechanisms

Just Herder
Professor of Interactive Mechanisms and Mechatronics
Head of Department of Precision and Microsystems Engineering
Delft University of Technology, The Netherlands

Abstract
Compliant mechanisms move due to elastic deformation of slender segments. As a result, they have no sliding friction, backlash, wear, noise, and require no lubrication, maintenance and assembly, typically at reduced cost. These advantages led to wide-spread application in high-end manufacturing equipment in semiconductor industry, scientific instrumentation, as well as many consumer products. To date, by far most compliant joints are planar in nature, typically based on notches, leaf springs or their combinations. However, with the advent of high quality 3D metal printing, a sheer endless shape design freedom has become available that we are just beginning to explore. This talk will present our approach to the synthesis of compliant mechanisms with spatially curved elastic segments. Starting with a screw-theory based approach for the geometrically non-linear characterization of load-deflection behaviour, a synthesis method is presented using a library of building blocks. Examples will be presented in large deflection precision stages and medical devices including catheter tips and body support systems.

Biography
Just Herder is a full professor of Interactive Mechanisms and Mechatronics, Chair of the Mechatronic System Design group and Head of Department of Precision and Microsystems Engineering at Delft University of Technology, from which university he also received his MSc and PhD degrees, both with honors. He has widely published in international peer-reviewed journals and conferences and has received several international awards. He is an ASME fellow, board member of several international conferences, associate editor of Mechanism and Machine Theory, and Editor-in-Chief of Mechanical Sciences. Seven start-up companies have emerged from his research and he holds over twenty patents in different areas of mechanism design. He held a part-time full professor position at the University of Twente, and visiting positions at Laval University, Canada, and at MIT, USA, as a Fulbright Visiting Scholar.

His research interest is in mechatronic systems with remarkable behavior and their applications, in particular in those mechanisms that effect or are affected in a special way by interaction with their environment, called Interactive Mechanisms. A long term goal is to establish Distributed Mechatronics, where motion, actuation and sensing are distributed along a compliant structure, with a high level of function integration, trending towards small length scales. To reach this goal, focus is placed on the development of new technology, methods and techniques, such as static balancing, dynamic balancing, compliant mechanisms, parallel kinematics, self-adaptability, distributed actuation and sensing. Applications fields include precision engineering and mechatronics, robotics, rehabilitation engineering, high-tech industry, MEMS.
KEYNOTE SPEECH 3
Past and Future Innovations with Mechanism Design

Marco Ceccarelli
President of IFToMM
Professor of Mechanics of Machines
Laboratory of Robotics and Mechatronics
University of Roma Tor Vergata, Italy
Beijing Advanced Innovation Center for Intelligent Robots and Systems
Beijing Institute of Technology, Beijing, China

Abstract
Challenges for Robotics and Mechatronics can be considered from several viewpoints in technical, social, and financial ones as due to new designs and applications. In this keynote paper new horizons are discussed in terms of innovation issues coming from Mechanism Design. The attention is focused on challenging aspects that are related to the mechanical structure of a modern system as for the structure and operation when considering assigned tasks either in substituting or helping human operators. The keynote speech presents aspects emphasizing the role of mechanism design in system developments as based on the fact that the action in performing tasks, either in coordination or not with human operators, is of mechanical nature due to motion and force transmission goals of the operation. The challenges of mechanism design are presented both in terms of technical solutions and community activity, since each of them depends, impacts, and generates each other. Examples of past and current solutions are presented to show how a mechanism design can be determinant for a design with novel successful achievements.

Biography
Marco Ceccarelli received his Ph.D. in Mechanical Engineering from La Sapienza University of Rome, Italy, in 1988. He is Professor of Mechanics of Machines at the University of Roma Tor Vergata, Italy, where he chairs LARM2: Laboratory of Robot Mechatronics.

His research interests cover subjects of robot design, mechanism kinematics, experimental mechanics with special attention to parallel kinematics machines, service robotic devices, mechanism design, and history of ma-chines and mechanisms whose expertise is documented by several published papers in the fields of Robotics. He has been visiting professor in several universities in the world and since 2014 at Beijing Institute of Technology. He is ASME fellow and doctor honoris causa from several Universities. Professor Ceccarelli serves in several Journal editorial boards and conference scientific committees. He is editor of the Springer book series on Mechanism and Machine Science (MMS) and History of MMS. Professor Ceccarelli is the President of IFToMM, the Inter-national Federation for the Promotion of MMS. He has contributed to ISRM since 2010 and was in the Scientific Committee until 2016. He has started several IFToMM sponsored conferences including MEDER (Mechanism Design for Robotics) and MUSME (Multibody Systems and Mechatronics).

KEYNOTE SPEECH 4
Technology Development & Application of Robotics in Rehabilitation Medicine

Jen-Yuan (James) Chang
Distinguished Professor
Department of Power Mechanical Engineering
National Tsing Hua University, Taiwan
CTO
Mechanical and Mechatronics Systems Research Laboratories
Industrial Technology Research Institute (ITRI), Taiwan

Abstract
To contend with an aging population and limitation of availability of healthcare manpower, the adaptation of robotics in rehabilitation has increased, in particular in developed countries where aging is playing significant role in resulting in long-term disabilities. Strokes, which are primary contributed by hypotonia and chronic hemiparesis, have been found to be one of the major causes for the long-term disabilities, leading to limb/hand functional impairments in patients. Due to limitation of muscle motor capabilities, hypereexcitability of the stretch reflex is commonly found in stroke patients. The so-called “stiffness” or “tightness” of muscles in the stroke patients is referred to the muscle spasticity which is caused by hypereexcitability of motoneuons. In medical practices, it is found that with precise and repeated range of motion (ROM) exercises, the aforementioned flexor hypereexcitability can be reduced. In present practices, the ROM exercises are operated by therapist’s hands to temporarily reduce the severity of spasticity. In evidence-based medicine, it is demonstrated that with robot-assisted rehabilitation, the high-repetitive and high-precision movements can greatly improve the quality of rehabilitation for stroke patients. In this seminar, viewing the robotic rehabilitation devices as smart machines, Professor Chang will first discuss government’s strategic aims in long-term care and digital precision medicine as well as the global market trend in rehabilitation robots. Then the robotic technologies suitable for rehabilitation will be discussed by sharing his R&D experience in the development of wearable robotic assistive rehabilitation devices for hand/fingers, of which devices later obtained Taiwan FDA and ISO13485 certifications. Last but not the least, strategic approaches in transforming technologies into commercial products will be discussed in the context of combining university R&D, government resource as well as venture capital opportunities.

Biography
Jen-Yuan (James) Chang received the Ph.D. degree from Carnegie Mellon University, USA in 2001. He is a Distinguished Professor at National Tsing Hua University where he chairs the Vibrations, Mechatronics and Robotics Laboratories.

With a mix of IBM/Hitachi advanced magnetic disk drive R&D in Silicon Valley, California and academic careers in USA, New Zealand and Taiwan, Dr. Chang’s research in mechatronics, robotics, mechanical vibrations, dynamic systems and control, smart machinery and manufacturing have been archived in more than 21 granted patents, more than 70 journal papers, and 120 conference papers. Dr. Chang has served at various executive positions, including Division Chair in the Information Storage and Processing Systems Division and Vice Chair of Strategic Planning Committee of the American Society of Mechanical Engineers (ASME), where he received ASME ISPS Distinguished Speaker Award in 2019, Distinguished Institution Award in 2018, and Outstanding Contribution Award in 2011. His teaching and research have been honored with Outstanding Teaching Award and Outstanding Industry-University Research Award by NTHU as well as Excellent Young Investigator Award and Outstanding Research Award by Ministry of Science and Technology, Taiwan. He is a Fellow of the ASME.
## Session 1: Industrial and Service Related Robotics and Mechatronics

**Session Chair:** Professor Yusuke Sugahara, Tokyo Institute of Technology, Japan

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<td>12:00-12:20</td>
<td>Paper 56: An Experimental Characterization of the BIT Astronaut Robot</td>
<td>M. Ceccarelli, H. Li, T. Zheng, M. Yang</td>
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## Session 2: Kinematics and Dynamics of Multibody Systems

**Session Chair:** Prof. Dr.-Ing. Mathias Hüsing, RWTH Aachen University, Germany

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<td>11:00-11:20</td>
<td>Paper 15: Kinematics of a Planar Parallel Robot via Screw Theory: Details not Mentioned</td>
<td>A.L. Balmaceda-Santamaria, M.A. García-Murillo</td>
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<td>11:20-11:40</td>
<td>Paper 24: Dynamic Modeling for Spatial Revolute Joint with Clearances in Multibody Systems Based on HLCP</td>
<td>L. Li, S. Lyu, X. Ding</td>
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<td>11:40-12:00</td>
<td>Paper 39: Kinematic Analysis of (2-RRU)-URR Parallel Mechanism Performing 2R1T Output Motion</td>
<td>W.-h. Choi, Y. Takeda</td>
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## Session 3: Novel Robotic Systems

**Session Chair:** Professor Gim Song Soh, Singapore University of Technology and Design, Singapore

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<tr>
<td>13:50-14:10</td>
<td>Paper 18: Development and Optimization of an Intelligent Parking Slot Alloter and Billing System Based on Machine Learning and OCR</td>
<td>B.P. Dandumahanti, G.-c. Chen</td>
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<td>14:50-15:10</td>
<td>Paper 55: Dynamic Analysis and Motion Simulation of the 3 DOFs Waist Mechanism for Humanoid Robots</td>
<td>M. Penčič, B. Brkić, M. Ćavić, M. Rackov</td>
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### Session 4: Mechanism Synthesis, Analysis, and Design
Session Chair: Professor Giuseppe Carbone, University of Calabria, Italy

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<tr>
<th>Time</th>
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<td></td>
<td>Stiffness Analysis of a Aemi-symmetrical Three-Translation Delta-CU Parallel Robot</td>
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<td>15:50-16:10</td>
<td>Paper 09:</td>
<td>I. G&quot;org&quot;ul&quot;u, M. I. C. Dede, G. Carbone</td>
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<td></td>
<td>An Experimental Test Procedure for Validation of Stiffness Model: A Case Study for R-CUBE Parallel Mechanism</td>
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<td>16:10-16:30</td>
<td>Paper 26:</td>
<td>N. Vu Linh, C.-H. Kuo</td>
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<td>Performance Evaluation of a Class of Gravity-Compensated Gear-Spring Planar Articulated Manipulators</td>
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<td>16:30-16:50</td>
<td>Paper 51:</td>
<td>A. Fomin, W. Ivanov, V. Glazunov</td>
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<td>Design and Analysis of a Mechanism for Spherical Surface Processing</td>
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<td>16:50-17:10</td>
<td>Paper 54:</td>
<td>W.-T. Chang, D.-Y. Yang</td>
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<td>A Short Note on Equivalent Four-Bar Linkages of Direct-Contact Mechanisms</td>
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<td>A Motion Control System to Use Robots at 100 Times the Earth's Gravity</td>
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### Session 5: Modelling and Simulation
Session Chair: Professor Chao-Chieh Lan, National Cheng Kung University, Taiwan

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<td>15:30-15:50</td>
<td>Computationally Efficient Cable Force Calculation outside the Wrench-Feasible Workspace</td>
<td>R. Boumann, T. Bruckmann</td>
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<td>15:50-16:10</td>
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<td>F. Bruder, L. Mikelsons</td>
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<td>Towards Grey Box Modeling in Modelica</td>
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<td>Workspace Modelling of a Parallel Robot with Relative Manipulation Mechanisms Based on Optimization Methods</td>
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<td>16:30-16:50</td>
<td>Paper 28:</td>
<td>K.-L. Hsu, Y.-N. Chen</td>
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<td>Disk Cam Mechanisms with a Translating Follower Having Double Oblique Flat Faces</td>
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<td>16:50-17:10</td>
<td>Paper 40:</td>
<td>Q. H. Luong, J. Jong, Y. Sugahara, D. Matsuura, Y. Takeda</td>
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<td>A 3-dimensional Dynamic Model of the Aerotrain and the Horizontal Tail Effect on the Longitudinal Stability</td>
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<td>17:10-17:30</td>
<td>Paper 07:</td>
<td>A. Jomartov, A. Tuleshov, M. Kuatova</td>
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<td>Dynamic Model of a Crank Press in the Process of Braking</td>
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Session 6-2: Special Session on Advances in Medical Robotics II

Session Chair: Professor Terence Essomba, National Central University, Taiwan

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<th>Time</th>
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<tr>
<td>10:40-11:00</td>
<td>Paper 35: Real-Time Resolution of the Forward Kinematic Model for a New Spherical Parallel Manipulator</td>
<td>H. Saafi, M.A. Laribi, S. Zeghloul</td>
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<tr>
<td>11:00-11:20</td>
<td>Paper 50: A Low-Cost 6-DoF Master Device for Robotic Teleoperation</td>
<td>J. Sandoval, M.A. Laribi, S. Zeghloul</td>
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Session B: Historical Development in Robotics and Mechatronics

Session Chair: Professor Marco Ceccarelli, University of Rome Tor Vergata, Italy

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<th>Time</th>
<th>Paper</th>
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<tr>
<td>10:20-10:40</td>
<td>Paper 12: The Exhibit of Industrial Robots Based on Concepts of Technology Education: Take &quot;Smart Manufacturing Experience Zone&quot; at National Science and Technology Museum as an Example</td>
<td>J.-L. Lin, C.-Y. Lin</td>
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**MAP OF CONFERENCE SITE**

Walk from the “Gongguan” MRT (Taipei Metro) station (G07)

**Transportation to Conference Site**

National Taiwan University of Science and Technology (Taiwan Tech) is located in the Taipei downtown area about a ten-minute walk from the “Gongguan” MRT (Taipei Metro) station (G07). International visitors can fly to Taipei by using either Taiwan Taoyuan International Airport (TPE) or Taipei Songshan Airport (TSA). Public transportation, e.g., city metro, buses, taxis, and bikes, are safe and easily accessible to travel around Taipei city.

**Airport**

There are two airports available for you: "Taoyuan International Airport" and "Taipei Songshan Airport".

**Taoyuan International Airport (TPE)** is the most important international aviation hub of Taiwan. Many cities have direct flights to get there such as Los Angeles, San Francisco, Dubai, Singapore, Seoul, Tokyo, and Hong Kong. It has airport metro to Taipei Main Station, taking around 40 minutes by Express trains.

On the other hand, **Taipei Songshan Airport (TSA)** is a mid-size commercial airport located in the metropolitan area of Taipei city. It has scheduled flights serving domestically in Taiwan, and also to China, South Korea, and Japan. Transportation from the airport to Taiwan Tech is convenient. Passengers can take direct buses (Line 275) or taxi, which only takes about 30 and 15 minutes, respectively.

**Metro (MRT)**

Metro is the most efficient transport to travel around the city. It has seven lines passing a number of scenic spots and transport hubs such as Taoyuan Airport, Shihlin, Tamsui, Ximenting, and Chiang Kai-Shek Memorial Hall. A single trip costs NT$20-65 based on the distance and a one-day ticket costs NT$200. The closest metro station to the conference site is Gongguan station (G07) of Green Line via Exit 2.

**City Bus**

There are over 300 bus routes in the city. Shihlin, Chungshiao East Road, and Jhonghua Road are all important transfer places. Besides, you can take the bus near almost each metro station to those scenic spots. A one-section journey costs NT$15.
CULTURAL TOUR  29 October, 12:30-18:00

Destination ① ☑ ☑ Yangmingshan National Park
Of all Taiwan's national parks, Yangmingshan is the one located closest to a metropolitan center. Yangmingshan features a widely varying terrain, diverse ecology, and is home to numerous protected species. One of the most distinctive features in the park is the “Flower Clock,” composed of a variety of colorful seasonal flowers. The Yangmingshan area also possesses a wealth of geothermal resources, with hot springs having differing compositions depending on their location in the park.

Destination ② ☑ ☑ Yangmingshan Chungshan Hall
Chungshan Hall in Yangmingshan National Park was built in 1965 during the presidency of Chiang Kai-shek in memorial of the centennial birthday of Dr. Sun Yat-sen. Designed by architect Hsiu Tse-lan, the hall is set into the mountainside surrounded by greenery. The classical Chinese-style of the exterior is echoed by the elegance of the interior. The hall once served as the meeting place for the National Assembly. It is also frequently used for receiving foreign dignitaries, holding state banquets and other important events.

Destination ③ ☑ ☑ National Palace Museum
The Taipei National Palace Museum is a world-class museum that hosts an eclectic collection of treasures kept by generations of Emperors ruling from the Forbidden City. In WWII, Nationalist troops seized the most important pieces in order to prevent invaders from ransacking China’s national treasures. A twist of fate eventually brought these treasures to Taiwan. The Taipei National Palace Museum is designed in the style of a Northern Chinese palace. The museum is home to hundreds of thousands of historical relics that make up the world’s most comprehensive and precious collection of ancient Chinese artifacts. The entire collection covers 5,000 years of China's historical and artistic achievements.
Gongguan station (G07)
To conference venue via Exit 2