



## Faculty Personnel Record

**SUNIL K. AGRAWAL**

Professor

Department of Mechanical Engineering

Department of Rehabilitation Medicine

Columbia University, New York, NY 10027

**Website:** <https://roar.me.columbia.edu>

**Telephone:** 212.854.2841;

**E-mail:** [sunil.agrawal@columbia.edu](mailto:sunil.agrawal@columbia.edu)

**Google Scholar:**

[https://scholar.google.com/citations?hl=en&user=zavGyr4AAAAJ&view\\_op=list\\_works&sortby=pubdate](https://scholar.google.com/citations?hl=en&user=zavGyr4AAAAJ&view_op=list_works&sortby=pubdate)

**Date:** April 2018

**Education:**

<u>School</u>	<u>Degree</u>	<u>Date</u>
Stanford University	Ph.D.	August, 1990
Ohio State University	M.S.	December, 1986
Indian Institute of Technology (Kanpur)	B. Tech.	May, 1984

**Title of Ph.D. Thesis:**

A Study of In-Parallel Manipulator Systems (Advisor: Prof. Bernard Roth)

**Principal Fields of Interest:**

Rehabilitation Robotics, Dynamics and Control, Optimization, Differential Flatness

**Career History:** (list in reverse chronological order)

Employer	Position	Beginning	Ending
Columbia University Mechanical Engineering	Professor	1/1/2013	Continuing
Columbia University Rehabilitation Medicine	Professor	8/1/2013	Continuing
Scuola Superiore Sant'Anna Pisa, Biorobotics Institute	Visiting Professor	11/1/2016	5/1/2017
University of Ulster Northern Ireland, Robotics	Professor	4/1/2013	12/1/2015
Hanyang University (World Class Univ. Program)	Visiting Professor	8/1/2009	7/31/2013
Technical University of Stuttgart (Humboldt US Senior Scientist Award)	Visiting Professor	6/1/2008	8/31/2008
Technical University of Darmstadt (Humboldt Bessel Prize)	Visiting Professor	6/1/2003	8/31/2003
NIST - Intelligent Systems Division	Guest Researcher	1/1/2003	9/1/2004
University of Delaware Mechanical Engineering	Professor	9/1/2002	12/31/2012
Eglin Air Force Base Munitions Directorate	Senior Scientist	3/1/2001	9/1//2001
California Inst. of Tech. Control and Dynamic System	Visiting Associate	1/1/1998	6/1//1998
University of Delaware Mechanical Engineering	Associate Professor	4/1/1996	8/31/2002
Ohio University Mechanical Engineering	Associate Professor	8/1/1995	3/31/1996
Ohio University Mechanical Engineering	Assistant Professor	9/1/1990	8/31/1995

## **SUNIL K. AGRAWAL**

### ***Current Professional Organization Membership:***

American Society of Mechanical Engineers (ASME): Fellow  
American Institute of Medical and Biological Engineering (AIMBE): Fellow  
Institute of Electrical and Electronics Engineers (IEEE): Senior Member

### ***External Awards Received:***

***Machine Design Award, ASME, 2016 (American Society of Mechanical Engineering):***  
Citation “*For seminal contributions to design of robotic exoskeletons for gait training of Stroke patients*”

***Robotics and Mechanisms Award, ASME, 2016 (American Society of Mechanical Engineering):*** Citation “*For cumulative contributions and international leading figure in Mechanical design and robotics*”

***Fellow of AIMBE, 2016 (American Institute of Medical and Biological Engineering):***  
Citation “*For Outstanding contributions in designing intelligent innovative rehabilitative machines and training algorithms for rehabilitation of patients with neurological disorders*”

***Alexander von Humboldt Foundation U.S. Senior Scientist Award, Germany, 2007:***  
Citation “*Prize for Applied Mechanics*”

***Fellow of ASME (American Society of Mechanical Engineering), 2004.***

***Friedrich Wilhelm Bessel Research Award, Alexander von Humboldt Foundation, Germany, 2002:*** Citation “*Prize for Mechanics and Dynamics*”

***The Presidential Faculty Fellow Award, the White House, 1994:*** Citation  
“*Demonstrated Excellence and Continued Promise in Scientific and Engineering Research*”

***Fritz and Dolores Russ Research Award, Ohio University, 1994.***

***Best All Rounder Student Gold Medal, IIT, Kanpur, 1984***

### ***Technical Paper Awards:***

***Honorable Mention, 39th ASME Mechanisms and Robotics Conference, Boston, 2015.***  
Title: “*Wearable Upper Body Suit for Assisting Human Load Carriage*”,  
Authors: Joon Park, Paul Stegall, S. Yarlagadda, J.Tierny, S. Sharma, and S. K. Agrawal

**Best Student Paper, 2012 IEEE International Conference on Robotics and Automation  
Minneapolis, 2012.**

Title: "Cable Driven ARm EXoskeleton (CAREX): Transition from Experiments on a  
Mechanical Arm to Human Arm"

Authors: Ying Mao and Sunil K. Agrawal

**Best Paper, 35th ASME Mechanisms and Robotics Conference, Washington DC, 2011.**

Title: "Reciprocal Screw-Based Force-Closure of Cable-Driven Closed Chains ",

Authors: S. K. Mustafa and Sunil K. Agrawal

**MSC Software Simulation Award, 31st ASME Mechanisms and Robotics Conference,  
2007.**

Title: "Motion Planning of a Tractor with a Steerable Trailer Using Differential  
Flatness",

Authors: Ji-Chul Ryu, Jaume Franch, and Sunil K. Agrawal

**Biomimicry Prize, 28th ASME Mechanisms and Robotics Conference, 2004.**

Title: " Biologically Inspired Design of Small Flapping Wing Air Vehicles Using 4-Bar  
Mechanisms and Quasi-Steady Aerodynamics ",

Authors: R. Madangopal and Sunil K. Agrawal

**Service:** Department of Mechanical Engineering, Columbia University

Activity	Beginning	Ending
Chair of Graduate Program	9/1/2014	Continuing

**Professional Services:**

**Journal Editorial Board:**

Activity	Beginning	Ending
<b>IEEE Robotics and Automation Letters Associate Editor</b>	8/1/2015	Continuing
<b>IEEE Systems Journal, 2015 Guest Co-Editor, Vol. 10, No. 3, 2016 Title: Systems-related Topics in Robotics &amp; Automation for human health</b>	9/1/2014	12/31/2016
<b>Advanced Robotics, 2011 Guest Co-Editor, Vol. 25, No. 15, 2011 Title: Clinical-Based, Task-Specific and Subject-Oriented Approaches Essential to Effective Robotics Rehabilitation</b>	9/1/2009	1/1/2011
<b>IEEE TNSRE, 2009</b>	9/1/2007	3/1/2009

***Guest Co-Editor, Vol. 17, No. 1, 2009***

***Title:*** Special Section on Lowe Extremity Exoskeletons for Assistance and Training of Human Gait.

***IEEE TNSRE*** 12/1/2007 3/1/2009  
***Associate Technical Editor***

***Int. J. of Robotics Research, 2008*** 9/1/2006 3/1/2008  
***Guest Co-Editor, Vol. 27, No. 2, 2008***

***Title:*** Special Section on ASME IMECE ARDC 2006 Machines for Human Assistance and Augmentation

***ASME J. DSMC*** 6/1/2004 5/31/2006  
***Associate Technical Editor***

***IEEE Trans. On Mechatronics, 2006*** 7/1/2004 3/1/2006  
***Guest Co-Editor, Vol. 11, No. 2, 2006***

***Title:*** Guest editorial introduction to the focused section on Biomimetics and novel aspects in robotics

***ASME J. of DSMC, 2006*** 7/1/2004 3/1/2006  
***Guest Co-Editor, Vol. 28, No. 1, 2006***

***Title:*** Special Issue on Novel Robotics and Control

***Mechanical Based Design of Structures and Machines*** 9/1/2002 8/31/2008  
***Associate Technical Editor***

***IEEE CST*** 1/1/2001 12/31/2002  
***Associate Technical Editor***

***ASME J. of Mechanical Design*** 8/1/2000 7/31/2003  
***Associate Technical Editor***

***Multi-body Dynamics*** 8/1/1996 7/31/2003  
***Associate Technical Editor***

## **SUNIL K. AGRWAWAL**

### ***Consulting Record:***

Firm	Beginning	Ending
Schlumberger Corporation (SLB)	6/1/2007	12/31/2008
Bally Ribbon Mills	8/1/2005	3/1/2006
Pathway Technologies	1/1/2000	12/02/2002
Xerox, PARC	3/1/1999	12/1/2000

### ***Patents Granted***

Title	Number	Date
<b><i>Active movement training devices, methods, and systems</i></b> Agrawal, S. K., Zanotto, D., Stegall, P.	9,662,526	May 30, 2017
<b><i>Wearable cable-driven exoskeleton for functional arm Training</i></b> , Agrawal, S. K., Mao, Y., and Scholz, J. P	9,144,528	Sep. 29, 2015
<b><i>Passive Swing Assist Leg Exoskeletons</i></b> Agrawal, S. K. and Banala, S. K.	8,900,167	Dec 2, 2014
<b><i>Powered Orthosis Systems and Methods</i></b> Agrawal, S. K., Winfree, K, Stegall, P., Scholz, J. P.	8,771,208	July 8, 2014
<b><i>Powered Mobility Systems and Methods</i></b> Agrawal, S. K., Galloway, J. C., Chen, X., Ragonesi, C., Liang, S., Dolph, S., Schoepflin, Z.	8,731,738 B2	May 20, 2014
<b><i>Vibratory Feedback Systems and Methods</i></b> Agrawal, S. K., Winfree, K, Hilgart, D.	8,692,675	Apr 8, 2014
<b><i>Upper Arm Wearable Exoskeleton</i></b> Agrawal, S. K., Dubey, V., Gangloff, J., Brackbill, E.	84091181	Apr 3, 2013
<b><i>Powered Orthosis</i></b> Agrawal, S. K. and Banala, S. K.	8,147,436	Apr 3, 2012
<b><i>Intelligent Powered Mobility for Infants and</i></b>	8,090,488B2	Jan 3, 2012

### ***Special Needs Children***

Agrawal, S. K., Galloway, J. C., and Ryu, J. C.

### ***Ankle Foot Orthosis Device***

7,878,993

Feb 1, 2011.

Agrawal, S. K., Agrawal A., Banala, S. K., Macleod, S. B.

### ***Mechanism for Biaxial Rotation of a Wing and Vehicles Containing Such Mechanisms***

7,651,051

Jan 26, 2010

Agrawal, S. K., McIntosh, S., and Khan, Z.

### ***Gravity Balanced Orthosis Apparatus***

7,544,155

June 9, 2009

Agrawal, S. K., Fattah, A., Banala, S. K.

### ***Passive Gravity Balanced Assistive Device for Sit-to-stand Tasks***

7,601,104

Oct 13, 2009

Agrawal, S. K., Fattah, A., Hamnett, J.

### ***Autonomous Rolling Robot***

6,414,457

July 2, 2002

Agrawal, S. K. and Bhattacharya, S.

### ***Pending Patent Applications***

Title	Number	Date
<b><i>Back Brace</i></b> CJ Kim, J Ring, J Nijssen, S Pratt, S Agrawal, P Stegall, J Park	201815677869	Feb 15, 2018
<b><i>Gait Analysis Devices, Methods, and Systems</i></b> Agrawal, S. K., Zanutto, D., and Boggs, E.M.	20170055880	Mar 2, 2017
<b><i>Spinal Treatment Devices, Methods, and Systems</i></b> Agrawal, S. K., Park, J. H., and Stegall, P.	20170042717	Feb 16, 2017
<b><i>Human Movement Research, Therapeutic, and Diagnostic Devices, Methods, and Systems</i></b> Agrawal, S. K., Vashista, V., Kang, J., Xin, J.	20170027803	Feb 2, 2017
<b><i>Gait and Mobility Assessment Systems and Methods</i></b> Winfree, K., Pretzer-Aboff, I., Agrawal, S. K.	20160058326	Mar 3, 2016
<b><i>Active Movement Training Devices and Systems</i></b> Winfree, K., Pretzer-Aboff, I., Agrawal, S. K.	20150297934	Oct 22, 2015

**SUNIL K. AGRAWAL**

***Teaching Experience***

Term	Subject Number	Title	Role
<i>Spring 2017</i>	<i>MECEE 6614</i>	<i>Advanced Topics in Robotics</i>	<i>Instructor</i>
<i>Fall 2016</i>	<i>MECEE 4602</i>	<i>Introduction to Robotics</i>	<i>Instructor</i>
<i>Fall 2015</i>	<i>MECEE3409</i>	<i>Machine Design</i>	<i>Instructor</i>



## **SUNIL K. AGRAWAL**

### ***Books***

- *Kinematics, Dynamics, and Machine Design: 3<sup>rd</sup> Edition*  
(John Wiley and Sons, May 2016; Pages: 700)  
**Authors:** Prof. Kenneth J. Waldron, Prof. Gary Kinzel, and Sunil K. Agrawal
- *Differentially Flat Systems*, Marcel Dekker (Control Engineering Series)  
(Hardbound, ISBN 0-8247-5470-0, June 2004; Pages: 467)  
**Authors:** Prof. Hebertt Sira-Ramirez, Department of Electrical Engineering, CINVESTAV-IPN, Mexico and Sunil K. Agrawal
- *Optimization of Dynamic Systems*, Kluwer Academic Publishers, Dordrecht,  
Hardbound, ISBN 0-7923-5681-0, April 1999, Pages: 240  
**Authors:** Sunil K. Agrawal, University of Delaware & Prof. Brian C. Fabien,  
Mechanical Engineering, University of Washington, Seattle.

### ***Papers in Refereed Journals:***

- [Retraining of Human Gait-Are Lightweight Cable-Driven Leg Exoskeleton Designs Effective?](#) 2018  
X Jin, A Prado, SK Agrawal  
IEEE Transactions on Neural Systems and Rehabilitation Engineering 26 (4), 847-855
- [Wrench Capability of a Stewart Platform With Series Elastic Actuators](#) 2018  
C Ophaswongse, RC Murray, SK Agrawal  
Journal of Mechanisms and Robotics 10 (2), 021002
- [Robotic Spine Exoskeleton \(RoSE\): Characterizing the Three-dimensional Stiffness of the Human Torso in the Treatment of Spine Deformity](#) 2018  
JH Park, PR Stegall, DP Roye, SK Agrawal  
IEEE Transactions on Neural Systems and Rehabilitation Engineering
- [Improving Trunk-Pelvis Stability Using Active Force Control at the Trunk and Passive Resistance at the Pelvis](#) 2018  
M Khan, V Santamaria, S Agrawal  
IEEE Robotics and Automation Letters
- [A spring-loaded compliant neck brace with adjustable supports](#) 2018  
H Zhang, K Albee, SK Agrawal  
Mechanism and Machine Theory

- [Use Of Inertial Motion-capture System To Assess Kinematics In Adolescent Baseball Pitchers: spo147](#)  
Jean F Timmerberg, Rami Said, Terence Crossan, Sarah Lloyd, Matthew Naftilan, Nicole Schlobach, Isirame Omofuma, Sunil K Agrawal, Thomas Sean Lynch  
Journal of Orthopaedic & Sports Physical 48 (1), A267 2018
- [Force tracking control of an electro-hydraulic control loading system on a flight simulator using inverse model control and a damping compensator](#)  
J Zhao, G Shen, W Zhu, C Yang, SK Agrawal  
Transactions of the Institute of Measurement and Control 40 (1), 135-147 2018
- [An Active Neck Brace Controlled by a Joystick to Assist Head Motion](#)  
H Zhang, SK Agrawal  
IEEE Robotics and Automation Letters 3 (1), 37-43, 2018
- [Effects of Viscous Damping on Differential Flatness-Based Control for a Class of Under-Actuated Planar Manipulators](#)  
V Sangwan, SK Agrawal  
IEEE Control Systems Letters 2 (1), 67-72, 2018
- [Adaptation of Stability during Perturbed Walking in Parkinson's Disease](#)  
D Martelli, L Luo, J Kang, UJ Kang, S Fahn, SK Agrawal  
Scientific reports 7 (1), 17875 2017
- [Dizziness handicap inventory score is highly correlated with markers of gait disturbance](#)  
Damiano Zanotto, Erin M Mamuyac, Adam R Chambers, John S Nemer, John A Stafford, Sunil K Agrawal, Anil K Lalwani  
Otology & Neurotology 38 (10), 1490-1499 2017
- [Design and implementation of a novel modal space active force control concept for spatial multi-DOF parallel robotic manipulators actuated by electrical actuators](#)  
C Yang, J Zhao, L Li, SK Agrawal  
ISA transactions 2017
- [Walking With aBackpack Using Load Distribution and Dynamic Load Compensation Reduces Metabolic Cost and Adaptations to Loads](#)  
JH Park, P Stegall, H Zhang, S Agrawal  
IEEE Transactions on Neural Systems and Rehabilitation Engineering 25 (9), 1419-1430 2017
- [On the Adaptation of Pelvic Motion by Applying 3-dimensional Guidance Forces Using TPAD](#)  
J Kang, V Vashista, SK Agrawal 2017

IEEE Transactions on Neural Systems and Rehabilitation Engineering 25 (9) 1558-1567

[On the Adaptation of Pelvic Motion by Applying 3-dimensional Guidance Forces using TPAD](#)

J Kang, V Vashista, S Agrawal

IEEE Transactions on Neural Systems and Rehabilitation Engineering, 2017

[Effects of Virtual Reality Training With Trunk Support Trainer \(TruST\) on Postural Kinematics](#)

MI Khan, A Prado, SK Agrawal

IEEE Robotics and Automation Letters 2 (4), 2240-2247, 2017

[Estimating CoP Trajectories and Kinematic Gait Parameters in Walking and Running Using Instrumented Insoles](#)

H Zhang, D Zanotto, SK Agrawal

IEEE Robotics and Automation Letters 2 (4), 2159-2165, 2017

[Exploration of Two Training Paradigms Using Forced Induced Weight Shifting With the Tethered Pelvic Assist Device to Reduce Asymmetry in Individuals After Stroke](#)

L Bishop, M Khan, D Martelli, L Quinn, J Stein, S Agrawal

American Journal of Physical Medicine & Rehabilitation 96 (10), S135-S140, 2017

[Robot-driven downward pelvic pull to improve crouch gait in children with cerebral palsy](#)

J Kang, D Martelli, V Vashista, I Martinez-Hernandez, H Kim, SK Agrawal

Science Robotics 2 (8), ean2634, 2017

[Enhancing Seated Stability Using Trunk Support Trainer \(TruST\)](#)

MI Khan, V Santamaria, J Kang, BM Bradley, JP Dutkowsky, AM Gordon, SK Agrawal

IEEE Robotics and Automation Letters 2 (3), 1609-1616, 2017

[Kinematic Design of a Dynamic Brace for Measurement of Head/Neck Motion](#)

H Zhang, SK Agrawal

IEEE Robotics and Automation Letters 2 (3), 1428-1435, 2017

[Variable Damping Force Tunnel for Gait Training Using ALEX III](#)

P Stegall, D Zanotto, SK Agrawal

IEEE Robotics and Automation Letters 2 (3), 1495-1501, 2017

[Optimizing Stiffness and Dexterity of Planar Adaptive Cable-Driven Parallel Robots](#)

S Abdolshah, D Zanotto, G Rosati, SK Agrawal

Journal of Mechanisms and Robotics 9 (3), 031004 2017

[Design and Optimal Control of an Underactuated Cable-Driven Micro–Macro Robot](#)

L Barbazza, D Zanotto, G Rosati, SK Agrawal

IEEE Robotics and Automation Letters 2 (2), 896-903, 2017

[A novel functional calibration method for real-time elbow joint angles estimation with magnetic-inertial sensors](#)

G Ligorio, D Zanotto, AM Sabatini, SK Agrawal  
Journal of Biomechanics 54, 106-110, 2017

[Design of a 7-DOF Cable-Driven Arm Exoskeleton \(CAREX-7\) and a Controller for Dexterous Motion Training or Assistance](#)

X Cui, W Chen, X Jin, SK Agrawal  
IEEE/ASME Transactions on Mechatronics 22 (1), 161-172, 2017

[Optimal Design of a Reconfigurable End-Effector for Cable-Suspended Parallel Robots](#)

L Barbazza, D Zanotto, G Rosati, SK Agrawal  
Advances in Italian Mechanism Science, 267-275, 2017

[Motion Guidance for a Passive Robot Walking Helper via User's Applied Hand Forces](#)

YH Hsieh, YC Huang, KY Young, CH Ko, SK Agrawal  
IEEE Transactions on Human-Machine Systems 46 (6), 869-881, 2016

[MAXFAS: Mechatronic Arm Exoskeleton for Firearm Aim Stabilization](#)

DM Baechle, ED Wetzel, SK Agrawal  
Journal of Mechanisms and Robotics 8 (6), 061013, 2016

[Configuration robustness analysis of the optimal design of cable-driven manipulators](#)

JT Bryson, X Jin, SK Agrawal  
Journal of Mechanisms and Robotics 8 (6), 061006, 2016

[Direction-dependent adaptation of dynamic gait stability following waist-pull perturbations](#)

D Martelli, V Vashista, S Micera, SK Agrawal  
IEEE Transactions on Neural Systems and Rehabilitation Engineering 24 (12), 1304-1313, 2016

[Directed Functional Connectivity in Fronto-Centroparietal Circuit Correlates With Motor Adaptation in Gait Training](#)

V Youssofzadeh, D Zanotto, KF Wong-Lin, SK Agrawal, G Prasad  
IEEE Transactions on Neural Systems and Rehabilitation Engineering 24 (11), 1265-1275, 2016

[Gait Assessment with SoleSound Instrumented Footwear in Spinal Muscular Atrophy](#)

J Montes, D Zanotto, S Dunaway Young, R Salazar, DC De Vivo, S. Agrawal  
Muscle & Nerve, 2016

[Reducing Dynamic Loads From a Backpack During Load Carriage Using an Upper Body Assistive Device](#)

JH Park, P Stegall, SK Agrawal

Journal of Mechanisms and Robotics 8 (5), 051017, 2016

[Special Issue on Systems-Related Topics in Robotics and Automation for Human Health](#)

JM Azorin, SK Agrawal, S Shimoda

IEEE SYSTEMS JOURNAL 10 (3), 901-902, 2016

[Robot-Enhanced Mobility Training of Children With Cerebral Palsy: Short-Term and Long-Term Pilot Studies](#)

SK Agrawal, J Kang, X Chen, MJ Kim, Y Lee, SW Kong, H Cho, GJ Park

IEEE Systems Journal 10 (3), 1098-1106, 2016

[Validation of a footwear-based gait analysis system with action-related feedback](#)

S Minto, D Zanotto, EM Boggs, G Rosati, SK Agrawal

IEEE Transactions on Neural Systems and Rehabilitation Engineering 24 (9), 971-980, 2016

[Locomotor adaptation to an asymmetric force on the human pelvis directed along the right leg](#)

V Vashista, D Martelli, SK Agrawal

IEEE Transactions on Neural Systems and Rehabilitation Engineering 24 (8), 872-881, 2016

[Optimal design of cable-driven manipulators using particle swarm optimization](#)

JT Bryson, X Jin, SK Agrawal

Journal of mechanisms and robotics 8 (4), 041003, 2016

[A Novel Approach to Apply Gait Synchronized External Forces on the Pelvis Using A-TPAD to Reduce Walking Effort](#)

V Vashista, M Khan, SK Agrawal

IEEE Robotics and Automation Letters 1 (2), 1118-1124, 2016

[Force tracking control of an electro-hydraulic control loading system on a flight simulator using inverse model control and a damping compensator](#)

J Zhao, G Shen, W Zhu, C Yang, SK Agrawal

Transactions of the Institute of Measurement and Control, 0142331216651326, 2016

[Emotion rendering in plantar vibro-tactile simulations of imagined walking styles](#)

L Turchet, D Zanotto, S Minto, S Agrawal

IEEE Transactions on Affective Computing, 2016

[Robotic Assist-As-Needed as an Alternative to Therapist-Assisted Gait Rehabilitation](#)

S Srivastava, PC Kao, DS Reisman, JP Scholz, SK Agrawal

Int J Phys Med Rehabil 4 (370), 2, 2016

[Robust Automated Step Extraction From Time-Series Contact Force Data Using the PDShoe](#)

KN Winfree, I Pretzer-Aboff, SK Agrawal  
IEEE Transactions on Neural Systems and Rehabilitation Engineering 23 (6), 1012-1019

[Assist-as-needed robot-aided gait training improves walking function in individuals following stroke](#)

S Srivastava, PC Kao, SH Kim, P Stegall, D Zanotto, JS Higginson, SK Agrawal, JP Scholz  
IEEE Transactions on Neural Systems and Rehabilitation Engineering 23 (6), 956-963, 2015

[Effect on wrench-feasible workspace of cable-driven parallel robots by adding springs](#)

Q Duan, V Vashista, SK Agrawal  
Mechanism and Machine Theory 86, 201-210, 2015

[Second Spine: upper body assistive device for human load carriage](#)

JH Park, X Jin, SK Agrawal  
Journal of Mechanisms and Robotics 7 (1), 011012, 2015

[A passive swing-assistive planar external orthosis for gait training on treadmill](#)

A Mokhtarian, A Fattah, SK Agrawal  
Journal of the Brazilian Society of Mechanical Sciences and Engineering 37(1), 1-10, 2015

[Short-term Performance-based Error-augmentation versus Error-reduction Robotic Gait Training for Individuals with Chronic Stroke: A Pilot Study](#)

PC Kao, S Srivastava, JS Higginson, SK Agrawal, JP Scholz  
Physical medicine and rehabilitation international 2 (9), 2015

[Cable-driven robots](#)

SK Mustafa, WB Lim, G Yang, SH Yeo, W Lin, SK Agrawal  
Handbook of manufacturing engineering and technology, 2169-2228, 2015

[Human movement training with a cable driven arm exoskeleton \(carex\)](#)

Y Mao, X Jin, GG Dutta, JP Scholz, SK Agrawal  
IEEE Transactions on Neural Systems and Rehabilitation Engineering 23 (1), 84-92, 2015

[Muscle Synergies of Untrained Subjects during 6 min Maximal Rowing on Slides and Fixed Ergometer](#)

S Shaharudin, D Zanotto, S Agrawal  
Journal of sports science & medicine 13 (4), 793, 2014

[Design of a robotic mobility system with a modular haptic feedback approach to promote socialization in children](#)

X Chen, C Ragonesi, JC Galloway, SK Agrawal  
IEEE transactions on haptics 7 (2), 131-139, 2014

[Real-time estimation of glenohumeral joint rotation center with cable-driven arm exoskeleton \(CAREX\)—A cable-based arm exoskeleton](#)

Y Mao, X Jin, SK Agrawal

Journal of mechanisms and robotics 6 (1), 014502, 2014

[Muscle Synergy during Wingate Anaerobic Rowing Test of Collegiate Rowers and Untrained Subjects](#)

S Shaharudin, D Zanotto, S Agrawal

International Journal of Sports Science 4 (5), 165-172, 2014

[Parameter Design in Optimal Control Problems for Linear Dynamic Systems Using a Canonical Form](#)

UJ Jung, GJ Park, SK Agrawal

Journal of Dynamic Systems, Measurement, and Control 136 (1), 011014, 2014

[Force adaptation in human walking with symmetrically applied downward forces on the pelvis](#)

V Vashista, N Agrawal, S Shaharudin, DS Reisman, SK Agrawal

IEEE Transactions on Neural Systems and Rehabilitation Engineering 21 (6), 969-978, 2013

[Assisting versus repelling force-feedback for learning of a line following task in a wheelchair](#)

X Chen, SK Agrawal

IEEE Transactions on Neural Systems and Rehabilitation Engineering 21 (6), 959-968, 2013

[Walk-assist robot: A novel approach to gain selection of a braking controller using differential flatness](#)

CH Ko, KY Young, YC Huang, SK Agrawal

IEEE Transactions on Control Systems Technology 21 (6), 2299-2305, 2013

[Powered hip exoskeletons can reduce the user's hip and ankle muscle activations during walking](#)

T Lenzi, MC Carrozza, SK Agrawal

IEEE Transactions on Neural Systems and Rehabilitation Engineering 21 (6), 938-948, 2013

[The effect of step-synchronized vibration on patients with Parkinson's disease: Case studies on subjects with freezing of gait or an implanted deep brain stimulator](#)

KN Winfree, I Pretzer-Aboff, D Hilgart, R Aggarwal, M Behari, SK Agrawal

IEEE Transactions on Neural Systems and Rehabilitation Engineering 21 (5), 806-811, 2013

[Effects of complementary auditory feedback in robot-assisted lower extremity motor adaptation](#)

D Zanotto, G Rosati, S Spagnol, P Stegall, SK Agrawal  
IEEE Transactions on Neural Systems and Rehabilitation Engineering 21 (5), 775-786, 2013

[Rehabilitation exoskeleton design: Exploring the effect of the anterior lunge degree of freedom](#)

P Stegall, K Winfree, D Zanotto, SK Agrawal  
IEEE Transactions on Robotics 29 (4), 838-846, 2013

[Active and passive control of walk-assist robot for outdoor guidance](#)

CH Ko, KY Young, YC Huang, SK Agrawal  
IEEE/ASME Transactions on Mechatronics 18 (3), 1211-1220, 2013

[An Assistive Passive Pelvic Device for Gait Training and Rehabilitation Using Locomotion Dynamic Model](#)

A Mokhtarian, A Fattah, SK Agrawal  
Indian Journal of Science and Technology 6 (3), 4168-4181

[A Higher-Order Method for Dynamic Optimization of Controllable Linear Time-Invariant Systems](#)

D Zanotto, G Rosati, SK Agrawal  
Journal of Dynamic Systems, Measurement, and Control 135 (2), 021008, 2013

[Quantifying anti-gravity torques for the design of a powered exoskeleton](#)

D Ragonesi, SK Agrawal, W Sample, T Rahman  
IEEE Transactions on Neural Systems and Rehabilitation Engineering 21 (2), 283-288, 2013.

[Differentially Flat Design of a Closed-Chain Planar Underactuated 2-DOF System](#)

C Zhang, J Franch, SK Agrawal  
IEEE Transactions on Robotics 29 (1), 277-282, 2013

[Effect of robotic performance-based error-augmentation versus error-reduction training on the gait of healthy individuals](#)

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A Fattah, SK Agrawal, J Fitzgibbons

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K Pathak, SK Agrawal, E Messina

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[Modification of residual vibrations in elevators with time-varying cable lengths](#)

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[Analytics and motion planning of a novel four-wheel vehicle with expanding wheels](#)

SK Agrawal, J Yan, J Rochester

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[A flatness based approach to trajectory modification of residual motion of highrise elevators](#)

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SK Agrawal, T Veeraklaew

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[Planning and optimization of dynamic systems via decomposition and partial feedback linearization](#)

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[Robotic assembly in a free-floating work environment](#)

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[Hyper-redundant planar manipulators: motion planning with discrete modal summation procedure](#)

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SK Agrawal, D Tong, K Nagaraja  
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Conference on Intelligent Robots in Factory, Field, Space, and Service, 1195, 1994

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[Kinematic models of assembly primitives for free-floating robots](#)

SK Agrawal, G Desmier  
Intelligent Robots and Systems' 93, IROS'93. Proceedings of the 1993

[Kinematics and workspace of a rolling disk between planar manipulators](#)

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American Control Conference, 1993, 741-745, 1993

[Motion planning of a dual-arm free-floating manipulator with inertially fixed base](#)

S AGRAWAL, S SHIRUMALLA  
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[Inverse Kinematic Solutions of a Rolling Disk Between Two Planar Manipulators](#)

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[Optimal workspace designs of free-floating planar manipulators](#)

SK Agrawal, R Garimella, G Desmier  
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[Workspace boundaries of in-parallel manipulator systems](#)

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[Inertia matrix singularity of planar series-chain manipulators](#)

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Robotics and Automation, 1991. Proceedings., 1991 IEEE

[Equations of Motion of In-parallel Manipulator Systems](#)

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[Rate kinematics of in-parallel manipulator systems](#)

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Robotics and Automation, 1990. Proceedings., 1990 IEEE 1990

[An implementation of inverse kinematic functions for control of a redundant wrist](#)

CW Wampler, SK Agrawal  
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[Isotropic and uniform inertial and acceleration characteristics: Issues in the design of redundant manipulators](#)

O Khatib, S Agrawal  
Dynamics of Controlled Mechanical Systems, 259-270, 1989

## **SUNIL K. AGRAWAL**

### ***Selected Keynote Lectures***

- ICMD 2017, Beijing, Nov 20, 2017  
Title: “Robotics to Retrain and Restore Human Movements”
- International Symposium on Wearable and Rehabilitation Robotics, TIRR, Houston, Nov 5-8, 2017  
Title: “Retraining Gait Using a Tethered Pelvic Assist Device (TPAD) in Children with Cerebral Palsy”
- WearRACon2017, Beijing, Sept 14, 2017  
Title: “Robotics to Retrain and Restore Human Movements”
- 2017 Global Investment Summit and 8<sup>th</sup> Young Investor Forum, CKGSB, Shenzhen, May 15, 2017  
Title: “Robots for Human Movement Training”
- 3<sup>rd</sup> International Conference on Cable-driven Parallel Robots, Quebec City, Canada, Aug 1-4, 2017  
Title: “Cable-driven and Parallel-actuated Robots for Training of Human Gait, Posture, and Balance”
- MIME Distinguished Speaker Series, Oregon State University, May 5, 2017  
Title: “Robotics for Training of Human Gait, Posture, and Balance”
- 7<sup>th</sup> Annual Meeting of the Rocky Mountain Society of Biomechanics 2017, Estes Park, Colorado, April 7-8, 2017  
Title: “Robots for Human Movement Training”
- International Conference on Robotics and Automation for Humanitarian Applications (RAHA), Dec 18-20, 2016  
Title: “Cable-driven Robotic Devices for Human Movement Training”
- 9<sup>th</sup> International Conference on Intelligent Robotics and Applications, Aug 22-24, 2016  
Title: “*Tethered Pelvic Assist Device (TPAD) and Cable-driven Exoskeletons for Human Movement Training*”
- Singapore Robotics Games, Jan 29, 2015  
Title: “*Can Robots help restore functions of neural impaired adults and children?*”
- 38<sup>th</sup> ASME Mechanisms and Robotics Conference, Buffalo, Aug 17-20, 2014  
Title: “*Can Robots Help Retrain Functions of Neural Impaired Adults and Children?*”

- *IEEE Life Sciences Grand Challenges Conference*, Singapore, Dec 2-3, 2013  
Title: “*Restoring Human Functions after Neural Impairments: Challenges and Opportunities in the field of Rehabilitation Robotics*”
- *Workshop on Assistive and Surgical Robotics*, Hsinchu (Taiwan)  
May 28, 2012  
Presentation Title: “*Novel Robots for Functional Training of Neural Impaired Adults and Children*”
- *5<sup>th</sup> Workshop in Applied Robotics and Automation*, Bauru (Brazil)  
RoboControl-2012, June 14-16, 2012  
Presentation Title: “*Novel Robots for Functional Training of Neural Impaired Adults and Children*”
- *3<sup>rd</sup> IEEE/RAS-EMBS Conference on Biomedical Robotics and Biomechatronics*, Tokyo  
BIOROB-2010, Sept 26-29, 2010  
Presentation Title: “*Robotic Exoskeletons for Gait Training of the Motor Impaired*”
- *The 6<sup>th</sup> International Conference on Ubiquitous Robots and Ambient Intelligence*,  
Gwangju, Korea, Oct 29-31, 2009  
Presentation Title: “*Robotic Exoskeletons for Gait Assistance and Training of the Motor Impaired*”
- *Royal Academy of Engineering Workshop – Functional Rehabilitation of the Motor Impaired: Robotics and new Directions*, *Bournemouth University, England, June 18, 2009*  
Presentation Title: “*Robotic Exoskeletons for Gait Assistance and Training of the Motor Impaired*”
- *NIST Performance Metrics for Intelligent Systems Workshop*, Aug 19-21, 2008,  
Gaithersburg, VA, USA  
Presentation Title: “*Robotic Exoskeletons for Gait Assistance and Training of the Motor Impaired*”
- *International Conference on Intelligent Systems*, Dec 1-3, 2008, Bahrain  
Presentation Title: “*Exoskeletons for Gait Assistance and Training of Motor Impaired Subjects*”
- *United Cerebral Palsy Foundation 2008 Conference*, Washington DC  
Presentation Title: “*Early Mobility to Infants with Special Needs – Baby Robots*”
- *IEEE Workshop on Advanced Robotics and Its Social Impacts*, Dec 9-11, 2007, Hsinchu  
Presentation Title: “*Exoskeletons for Gait Assistance and Training of the Motor Impaired*”

- *International Mechanical Engineering Conference and Exposition of the ASME, 2006, Chicago, Robotics Technical Committee of the Dynamic Systems and Control Division*  
Presentation Title: “Passive and Active Exoskeletons for Gait Training of Motor Impaired Patients”
- *National Conference on Control and Dynamical Systems, IIT, Bombay, Jan 2005*  
Presentation Title: “Cable Suspended Robots: Dynamics and Control”

### ***Selected Invited Workshop Presentations***

- *Cerebral Palsy Foundation Pain Symposium* organized at American Academy of Cerebral Palsy and Movement Disorders 2016, Hollywood, Florida, Sept 20, 2016
- *Frontiers in Rehabilitation Robotics Workshop at American Academy of Physical Medicine and Rehabilitation Annual Assembly, New Orleans, Louisiana*  
Oct 20-23, 2016
- *Global Initiative of Academic Networks, VJTI, Mumbai, Aug 8-12, 2016*  
Title: Robotics for Human Movements
- *World Parkinson Coalition Scientific Update 2015.*  
Title: “Detection of Freezing of Gait Episodes Using Instrumented Footwear”
- *Workshop “Conservative Treatment of Childhood Scoliosis” at the Columbia College of Physicians and Surgeons, June 2015.*  
Presentation Title: “Dynamic Brace for Correction of the Abnormal Human Spine”
- *Workshop “New design principles and frontiers for wearable robotics” at the IEEE Conf. on Robotics and Automation, 2012, May 14, 2012.*  
Presentation Title: “Cable Driven Wearable Exoskeletons for Training of Arm Motions”
- *International Conference on Physical Therapy, AIIMS 2011, Nov. 6-7, 2011, New Delhi*  
Presentation Title: “Robotic Gait Training”
- *Cognitive Neuroscience Workshop, IEEE IROS Conf., Sept 25, 2011, San Francisco (organized by M. Asada, H. Ishiguro, K. Narioka)*  
Presentation Title: “Mobility Training of Infants and Toddlers Using Novel Mobile Robots and Interfaces”
- *IEEE EMBS Conference, Aug 31, 2011, Boston (organized by H. Krebs, MIT)*  
*Workshop on “Rehabilitation and Therapeutic Robotics for Upper and Lower Extremity”*  
Presentation Title: “Exoskeletons for Gait Assistance and Training of the Motor-Impaired”

- *IEEE EMBS Conference, Aug 31, 2011, Boston, Mini Symposium on “Exoskeletons for Functional Training” (organized by S. K. Agrawal)*  
Presentations: “*Exoskeletons for Gait Training of the Motor-Impaired*”,  
“*Mobility Training of Infants and Toddlers Using Novel Mobile Robots and Interfaces*”
- *Intl. UKIERI Workshop on Fusion of BCI and Assistive Robotics, July 7-8, 2011, Univ. of Ulster (organized by G. Prasad)*  
Presentation Title: “*Exoskeletons for Gait Assistance and Training of the Motor-Impaired*”
- *ASME DSCC Conference, Sept 12, 2010, Boston (organized by H. Krebs, MIT)*  
*Workshop on “Rehabilitation and Therapeutic Robotics for Upper and Lower Extremity”*  
Presentation Title: “*Exoskeletons for Gait Assistance and Training of the Motor-Impaired*”
- *Robotics Research Towards Better Quality of Life, IEEE ICRA, May 3-5, 2010.*  
Presentation Title: “*Exoskeletons for Gait Assistance and Training of the Motor-Impaired*”
- *Int. Conf. on Autonomous Unmanned Vehicles, Bangalore, India, April 3-4, 2009*  
Presentation Title: *Challenges in Flapping Wing Micro Air vehicle Design and Development*
- *Workshop on Lower Extremity Exoskeletons, IEEE BIOROB, Oct 19-22, 2008.*  
Presentation Title: “*Exoskeletons for Gait Assistance and Training of the Motor-Impaired*”
- *Workshop on Agricultural Robotics: Towards autonomous agriculture of tomorrow, IEEE Intl. Conference on Robotics and Automation, May 19, 2008, Pasadena*  
Presentation Title: “*A Streamlined Approach to Future Autonomous Farming*”
- *Workshop on Wearable Robots, IEEE Intl. Conference on Robotics and Automation, May 19, 2008, Pasadena*  
Presentation Title: “*Exoskeletons for Gait Assistance and Training of the Motor-Impaired*”
- *Robo Business Conference 2008, Pittsburgh, April 8-9, 2008*  
Presentation Title: “*Exoskeletons for Gait Training*”
- *EURON Winter School on Rehabilitation Robotics, March 30-April 4, 2008, Elche, Spain*  
Presentation Title: “*Exoskeletons for Gait Assistance and Training of the Motor-Impaired*”
- *International Conference on Infant Studies March 27-March 29, 2008, Vancouver*  
Presentation Title: “*Psychological Antecedents & Consequences of Powered Mobility in Infants*”



- *IEEE Symposium on Special Environment Robot Technology*, Jan 30, 2008, Tohoku University, Japan  
Presentation Title: “Autonomous Robots for Mobility and Handling: Integration of Control and Design”
- *EURON Winter School on Parallel Robots*, March 25-30, 2007, Benidorm, Spain  
“Control of Cable-Driven Parallel Robots”
- ICRA Workshop “Collision-Free Motion Planning for Dynamic Systems”, Rome, April 10, 2007  
Presentation Title: “Differential Flatness Based Planning and Control of Classes of Mobile Vehicles”
- IDGA Workshop *UAV Summit - Combat and Micro*, Washington DC, March 2005.  
Presentation Title: “Flapping Wing Micro Air Vehicles”
- Workshop on Constraints in Control, CC 1999, Alexandria, VA  
Presentation Title: “Planning and Optimization of Dynamic Systems Using Built-in Structures”

### ***Selected Recent Invited Seminars***

- Tsinghua University, Beijing, China  
Title: Robots for Characterizing and Training of Human Movements  
July 28, 2016
- Beihang University, Beijing, China  
Title: Robots for Characterizing and Training of Human Movements  
July 29, 2016
- Indian Institute of Technology, Mumbai, India  
Title: Robots for Characterizing and Training of Human Movements  
Aug 10, 2016
- Biorobotics Institute, Pisa, Italy  
Title: Cable-driven Robots for Training of Human Movements  
Nov 11, 2016
- Purdue University, Feb 5, 2016 (Host: Prof. Richard Voyles)  
Title: “*Tethered Pelvic Assist Device (TPAD) and Cable-driven Systems for Human Movement Training*”
- Northern Arizona University, Feb 15, 2016 (Host: Prof. Kyle Winfree)

Title: “*Tethered Pelvic Assist Device (TPAD) and Cable-driven Systems for Human Movement Training*”

- University of Twente, Enschede, Nov 13, 2015 (Host: Prof. Herman van der Kooij)  
Title: “Tethered Pelvic Assist Device (TPAD) for Human Movement Training”
- Blythedale Children Hospital Grand Rounds, Oct 29, 2015 (Host: Dr. Jason Carmel)  
Title: “*Training Mobility, Gait, and Posture Using Robotics*”
- University of Maryland, Oct 9, 2015 (Host: Prof. Jaidev Desai)  
Title: “*Tethered Pelvic Assist Device (TPAD) and Cable-driven Exoskeletons for Human Movement Training*”
- IIT, Patna (India), April 22, 2015 (Host: Prof. Atul Thakur)  
Title: “*Can Robots help Retrain Functions of Neural Impaired Adults and Children?*”
- SUNY Stony Brook, Dec 2 2014 (Host: Prof. Jeff Ge)  
Title: “*Can Robots in Functional Training of Neural Impaired Adults and Children?*”
- RPI, March 2014 (Host: Prof. John Wen)  
Title: “*Novel Robots for Functional Training of Neural Impaired Adults and Skills Acquisition in Infants*”
- Northwestern University, June 2013 (Host: Prof. Kevin Lynch)  
Title: “*Novel Robots for Functional Training of Neural Impaired Adults and Skills Acquisition in Infants*”
- Penn State University, April 10, 2012 (Host: Prof. A. Sinha)  
Title: “*Novel Robots for Functional Training of Neural Impaired Adults and Skills Acquisition in Infants*”
- Univ. of Houston, Jan 30, 2012 (Host: Prof. J. Contreras-Vidal)  
Title: “*Novel Robots for Functional Training of Neural Impaired Adults and Skills Acquisition in Infants*”
- Harvard University Wyss Institute, Dec 1, 2011 (Host: Prof. Connor Walsh)  
Title: “*Novel Robots for Functional Training of Neural Impaired Adults and Skills Acquisition in Infants*”
- Columbia University, Nov 18, 2011 (Host: Prof. Gerard Ateshian)  
Title: “*Novel Robots for Functional Training of Neural Impaired Adults and Skills Acquisition in Infants*”
- Vanderbilt University, Sept 12, 2011 (Host: Prof. Nabil Simaan)  
Title: “*Novel Robots for Functional Training of Neural Impaired Adults and Skills Acquisition in Infants*”

- Rehabilitation Institute of Chicago, Sept 8, 2011 (Host: Prof. Zev Rymer)  
Title: *“Mobility Training of Infants and Toddlers Using Novel Mobile Robots and Interfaces”*
- SKKU, Suwon (Korea), Dec 14, 2010 (Host: Prof. H. R. Choi)  
Title: *“Robotic Exoskeletons for Gait Training of Neuro-Impaired”*
- Osaka University, (Japan), Dec 7, 2010 (Host: Prof. Minoru Asada)  
Title: *“Mobility Training of Infants and Toddlers Using Robots”*
- KAIST, Daejeon (Korea), Nov 10, 2010 (Host: Prof. Dong-Soo Kwon)  
Title: *“Robotic Exoskeletons for Gait Training of Neuro-Impaired”*
- Seoul National University, Seoul (Korea), Oct 27, 2010 (Host: Prof. Frank Park)  
Title: *“Differential Flatness Based Design, Planning, and Control of Under-actuated Robots”*
- University of Southern California, College of Health Sciences , March 3, 2010  
(Host: Prof. Carolee Winstein)  
Title: *“Robotic Exoskeletons for Gait Training of Neuro-Impaired”*
- University of California, Berkeley, October 23, 2009 (Host: Prof. Masayashi Tomizuka)  
Title: *“Robotic Exoskeletons for Gait Training”*
- A. I. DuPont Hospital for Children, Wilmington, DE – Translational Science Seminar Series, April 27, 2009 (Host: Dr. Tariq Rahman)  
Title: *“Robotic Exoskeletons for Gait Assistance and Training of the Motor Impaired”*
- *University of Stuttgart*, July 29, 2008 (Host: Prof. Oliver Sawodny)  
Title: *Design of Differentially Flat Systems: New Paradigms Integrating Control and Design*
- *Schlumberger SRPC Paris*, July 7, 2008 (Host: Prof. Fathi Ghorbel)  
Title: *Towards New Robotic Paradigms Integrating Control within Design*
- *Johns Hopkins University, Pi Tau Sigma Seminar, Mechanical Engineering*, March 13, 2008 (Host: Prof. Noah Cowan)  
Title: *Robotics for Neuro-motor Training - Exoskeletons & Powered Mobility for Infants*
- *Univ. of Pennsylvania Grasp Laboratory Seminar*, Feb 22, 2008 (Host: Prof. Vijay Kumar)  
Title: *Robotic Exoskeletons for Gait Assistance and Training of Motor Impaired*
- *Ohio State University ME Seminar Series*, Feb 15, 2008 (Host: Prof. Jim Schmiedeler)  
Title: *Robotic Exoskeletons for Gait Assistance and Training of Motor Impaired*
- *Schlumberger Fuchinobe Tech Center (Japan)*, Jan 29, 2008 (Host: Dr. H. Tashiro)

- Title: *Autonomous Robots for Mobility and Handling: Integration of Control and Design*
- *Massachusetts Institute of Technology*, Jan 22, 2008 (Host: Prof. Harry Asada)  
Title: *Robotic Exoskeletons for Gait Assistance and Training of Motor Impaired*
  - *Northwestern University*, Jan 10, 2008 (Host: Prof. Kevin Lynch)  
“*Robotic Exoskeletons for Gait Assistance and Training of the Motor Impaired*”

## **SUNIL K. AGRAWAL**

### ***Doctoral Theses Supervised***

1. Jiyeon Kang, *Robotic Functional Gait Evaluation with a Tethered Pelvic Assist Device*, Dept. of Mechanical Engineering, Columbia University, 11/17.
2. Xin Jin, *A Novel Design of a Cable-driven Active Leg Exoskeleton (C-ALEX) and Gait Training with Human Subjects*, Dept. of Mechanical Engineering, Columbia University, 10/17.
3. Stegall, Paul, *Building Better Exoskeletons: Understanding How Design Affects Robot Assisted Gait Training*, Dept. of Mechanical Engineering, Columbia University, 10/16.
4. Park, Joon, *Wearable Torso Exoskeletons for Backpack Load Carriage and Correction of Spine Deformities*, Columbia University, 9/16.
5. Bryson, Josh, *Design of Cable-driven Open-Chain Systems*, Dept. of Mechanical Engineering, University of Delaware, 12/15.
6. Vashista, Vineet, *A Cable-driven Pelvic Robot: Human Gait Adaptation and Rehabilitation Studies*, Columbia University, 9/15.
7. Shaharudin, Shazlin, *Characterizing Human Kinematics and Kinetics during Rowing*, Biomechanics and Movement Science Program, University of Delaware, 2/14.
8. Winfree, Kyle, *PDShoe – Gait Synchronized Vibratory Feedback for Parkinson Patients*, Biomechanics and Movement Science Program, University of Delaware, 6/13.
9. Zhang, Cheng-Kun, *Differential Flatness and Design of Under-actuated Systems*, Dept. of Mechanical Engineering, University of Delaware, 12/12.
10. Chen, Xi, *“Robot-Assisted Mobility for Functional Training of Children with Special Needs”*, Dept. of Mechanical Engineering, University of Delaware, September 2012.
11. Mao, Y., *“CAREX: A Cable-driven Arm Exoskeleton for Functional Training of Arm Movement”*, Dept. of Mechanical Engineering, University of Delaware, June 2012.
12. Sangwan, V., *Differential Flatness Based Design, Planning, and Control for Classes of Under-actuated Systems”*, Dept. of Mechanical Engineering, University of Delaware, 2010.
13. Khan, Z., *Modeling, optimal kinematics, and flight control of bio-inspired flapping wing micro air vehicles*, Dept. of Mechanical Engineering, University of Delaware, 2009.
14. Ryu, J., *Integrated Planning and Control of Mobile Manipulators and Robots Using Differential Flatness*, Dept. of Mechanical Engineering, University of Delaware, 2009.

15. Banala, S., *Lower Extremity Exoskeletons for Gait Rehabilitation of Motor-Impaired Patients*, Dept. of Mechanical Engineering, University of Delaware, 2008.
16. Mankala, K., *Satellite Tethered Systems: Dynamics and Control*, Dept. of Mechanical Engineering, University of Delaware, May 2006.
17. Oh, S., *Cable Suspended Robots: Control Approaches and Applications*, Dept. of Mechanical Engineering, University of Delaware, April 2006.
18. Pathak, K., *Switched Potential Fields for Navigation and Control of Nonholonomic and Under-actuated Autonomous Mobile Robots*, Dept. of Mechanical Engineering, University of Delaware, Dec 2005.
19. Zhang, Y., *Modeling and Control of a Flexible Cable Transporter System with Arbitrary Axial Velocity*, Dept. of Mechanical Engineering, University of Delaware, June 2004.
20. Hao, Y., *A Practical Framework for Formation Planning and Control of Multiple Unmanned Ground Vehicles*, Dept. of Mechanical Engineering, University of Delaware, June 2004.
21. Pledgie, S., *An Integrated Approach to the Design of Linear Dynamic Network based Systems*, Biomechanics and Movement Science, University of Delaware, Sept 2002.
22. Ferreira, A., *Aspects of Flatness Based Optimal Planning and Control of Dynamic Systems*, Dept. of Mechanical Eng., University of Delaware, August 2001.
23. Faiz, N., *Real-time and Optimal Trajectory Generation for Nonlinear Systems*, Dept. of Mechanical Engineering, University of Delaware, Feb 1999.
24. Veeraklaew, T., *Extensions of Optimization Theory and New Computational Approaches for Higher-Order Dynamic Systems*, Dept. of Mechanical Engineering, University of Delaware, Dec. 1999. (Nominated as *Outstanding dissertation in Science and Engineering*, 1999-2000).
25. Xu, X., *New Approaches to Optimization of Linear Time-Varying Systems and Classes of Nonlinear Systems*, Dept. of Mechanical Engineering, University of Delaware, Feb 1999.
26. Annapragada, M., *Optimal N-body Operations in a Free-floating Work Environment*, College of Engineering, Ohio University, June 1999.

### ***Current Doctoral Students (Sponsor/Advisor)***

1. Khan, Moiz, *Postural Training of Children with Impairments*, Dept. of Mechanical Engineering, Columbia University, Expected 09/19. (sponsor)

2. Zhang, Haohan, *Assistance and Training of Head Drop Syndrome*, Columbia University, Expected 09/19, (sponsor)
3. Prado De La Mora. Jesus, *TBD*, Dept. of Mechanical Engineering, Columbia University, Expected 06/20. (sponsor)
4. Rosemarie C. Murray, *TBD*, Dept. of Mechanical Engineering, Columbia University, Expected 6/20. (sponsor)
5. Chawin Ophaswongse, *TBD*, Dept. of Mechanical Engineering, Columbia University, Expected 6/20. (sponsor)
6. Isirame Omofuma, *TBD*, Dept. of Mechanical Engineering, Columbia University, Expected 6/20. (sponsor)
7. Rand Hidayah, *TBD*, Dept. of Mechanical Engineering, Columbia University, Expected 6/21. (sponsor)
8. Biing Chwen Chang, *TBD*, Dept. of Mechanical Engineering, Columbia University, Expected 6/21. (sponsor)
9. Danielle M. Strammel, *TBD*, Dept. of Mechanical Engineering, Columbia University, Expected 6/22. (sponsor)
10. Tatiana Luna, *TBD*, Dept. of Mechanical Engineering, Columbia University, Expected 6/22. (sponsor)

***SUNIL K. AGRAWAL***

Recent Postdoctoral Associates

<i>Name</i>	<i>Period of Stay</i>	<i>Current Position</i>
Victor Santamaria	11/1/2017-continuing	Post-doc Researcher
Dario Martelli	1/1/2016-continuing	Post-doc Researcher
Damiano Zanotto	9/1/2013-8/31/2016	Assistant Professor Stevens Institute of Tech



## **SUNIL K. AGRAWAL**

### ***Outreach Efforts***

- *Frequent tours to Robotics and Rehabilitation Laboratory of K-12 students, high school teachers, undergraduate students, and their families*

### ***Recent News Articles***

*First Dynamic Spine Brace - Robotic Spine Exoskeleton - Characterizes Spine Deformities*  
<http://engineering.columbia.edu/press-releases/robotic-spine-exoskeleton>

*Robotic Device Improves Balance and Gait in Parkinson's Disease Patients (2017)*  
<http://engineering.columbia.edu/press-releases/agraawal-tpad-parkinsons>

*Robot-driven Device Improves Crouch Gait in Children with Cerebral Palsy (2017)*  
<http://engineering.columbia.edu/news/sunil-agraawal-cerebral-palsy-crouch-gait>

### ***Spinal Cord Injury Research Work***

<http://engineering.columbia.edu/news/sunil-agraawal-spinal-cord-injury-grant>

### ***Dynamic Braces for kids with scoliosis under Development***

<http://engineering.columbia.edu/dynamic-braces-kids-scoliosis-now-development>

### ***Easing Symptoms of Parkinson's Disease: SoleSound***

<http://newyork.cbslocal.com/video/10889380-dr-max-gomez-easing-symptoms-of-parkinsons/>

### ***Personalized Medicine: Robots to the Rescue, Columbia Engineering, Fall 2014***

[http://engineering.columbia.edu/web/newsletter/fall\\_2014/sunil\\_agraawal%E2%80%94personalized\\_medicine](http://engineering.columbia.edu/web/newsletter/fall_2014/sunil_agraawal%E2%80%94personalized_medicine)

### ***150<sup>th</sup> Anniversary Symposium: Columbia Engineering Renaissance. Motion***

<https://www.youtube.com/watch?v=sYCR4HQv5xo&index=8&list=PLpktWkixc1gUVD9eP22XPfZQeGgYMC2U0>

### ***Open House Showcases Robotics for Rehabilitation***

<http://engineering.columbia.edu/open-house-showcases-robotics-rehabilitation>

### ***Creating New Robotic Technology That Positively Impacts Lives***

<http://engineering.columbia.edu/sunil-agraawal-creating-new-robotic-technology-positively-impacts-lives>

**SUNIL K. AGRAWAL**

***Research Funding at Columbia University (2013-2017)***

**Current Support**

**Title:** Translational Research Projects (TRP) in Spinal Cord Injury RFA # 1502050120

**Project Role:** PI

**Supporting Agency:** New York State Department of Health

**Period of Performance:** 08/15/16 - 08/14/21

**Level of Funding/ My Portion:** \$5,033,354/\$4,000,000

**Title:** Pelvic Assist Robotic Devices for Balance Training During Stair Climbing

**Project Role:** PI

**Supporting Agency:** New York State Spinal Cord Injury Research Board

**Period of Performance:** 03/01/17 - 02/28/22

**Level of Funding/ My Portion:** \$242,500

**Title:** Joint Research on Intelligent Wheel Chair with Dynamic Brace System

**Project Role:** PI

**Supporting Agency:** Beijing Goodoing Speed Smart, Co., Ltd.

**Period of Performance:** 12/13/16 - 12/12/19

**Level of Funding/ My Portion:** \$300,000

**Title:** Robotic rehabilitation to promote recovery of forelimb function after cervical SCI in rats

**Project Role:** PI

**Supporting Agency:** New York State Spinal Cord Injury Research Board (Subaward from CUNY)

**Period of Performance:** 11/01/17 - 10/31/19

**Level of Funding/ My Portion:** \$161,156

**Title:** NRI: Collaborative Research: Dynamic Braces for the Quantification and Treatment of Abnormal Curves in the Human Spine

**Project Role:** PI

**Supporting Agency:** National Science Foundation

**Period of Performance:** 09/01/15 - 08/31/18

**Level of Funding/ My Portion:** \$861,996

**Title:** Physical and Mental Fatigability in Late Life Clinical Populations

**Project Role:** PI

**Supporting Agency:** National Institutes of Health (Subaward from Research Foundation for Mental Hygiene, Inc.)

**Period of Performance:** 09/01/16 - 04/30/18

**Level of Funding/ My Portion:** \$129,446

**Title:** A Novel Light-Weight Cable-Driven Active Leg Exoskeleton (C-ALEX) for Training of Human Gait

**Project Role:** PI

**Supporting Agency:** National Science Foundation

**Period of Performance:** 01/01/13 - 09/30/18

**Level of Funding/ My Portion:** \$659,000

**Title:** CPS: Synergy: Multi-Robot Cyberphysical System for Assisting Young Developmentally-Delayed Children in Learning to Walk

**Project Role:** PI

**Supporting Agency:** National Science Foundation (Subaward from Harvard University)

**Period of Performance:** 10/01/13 - 09/30/18

**Level of Funding/ My Portion:** \$300,000

**Title:** EAGER: NSF-JST Program on Robotics for Rehabilitation and Medicine

**Project Role:** PI

**Supporting Agency:** National Science Foundation

**Period of Performance:** 06/30/13 - 08/31/18

**Level of Funding/ My Portion:** \$46,484

### **Selected Pending Support**

### **Selected Completed Projects**

**Title:** SoleSound: A Fully Portable Instrumented Footwear for Accurate Gait Analysis

**Project Role:** PI

**Supporting Agency:** Columbia-Coulter Translational Research Partnership

**Period of Performance:** 07/01/15 - 06/30/17

**Level of Funding/ My Portion:** \$105,586

**Title:** Robot Enhanced Mobility II: The Emergence of Mobility and Socialization in Young Children

**Project Role:** PI at Columbia (PI at Univ. of Delaware – J. Cole Galloway)

**Supporting Agency:** National Science Foundation

**Period of Performance:** 06/01/13 - 05/31/16

**Level of Funding/ My Portion:** \$500,000/\$250,000

**Title:** CAREX II: A Cable-Driven Arm Exoskeleton for Neural Rehabilitation for Joint Research

**Project Role:** PI

**Supporting Agency:** NYU Rusk Rehab Center

**Period of Performance:** 06/01/13 - 05/31/18  
**Level of Funding/ My Portion:** \$75,000

**Title:** Robotic Assisted Gait Training of Individuals with Incomplete Spinal Cord Injury  
**Project Role:** PI  
**Supporting Agency:** NY Department of Health/Spinal Cord Injury Board  
**Period of Performance:** 2015  
**Level of Funding/ My Portion:** \$210,000

**Title:** Spinal Cord Injury Research Institutional Support  
**Project Role:** PI  
**Supporting Agency:** NY Department of Health/Spinal Cord Injury Board  
**Period of Performance:** 2016  
**Level of Funding/ My Portion:** \$337,216

**Title:** Spinal Cord Injury Research Institutional Support  
**Project Role:** PI  
**Supporting Agency:** NY Department of Health/Spinal Cord Injury Board  
**Period of Performance:** 2015  
**Level of Funding/ My Portion:** \$250,000

**Title:** Warrior Web Program  
**Project Role:** Columbia PI/Univ. of Delaware PI  
**Supporting Agency:** NY Department of Health/Spinal Cord Injury Board  
**Period of Performance:** 2013-2015  
**Level of Funding/ My Portion:** XXX/\$364,855

**Title:** Spinal Cord Injury Research Institutional Support  
**Project Role:** PI  
**Supporting Agency:** NY Department of Health/Spinal Cord Injury Board  
**Period of Performance:** 2014  
**Level of Funding/ My Portion:** \$200,000

**Title:** Arm Exoskeleton for Aim Stabilization  
**Project Role:** PI  
**Supporting Agency:** Army Research Laboratory  
**Period of Performance:** 2013-2014  
**Level of Funding/ My Portion:** XXX/\$69,514

**Title:** Robotic Exoskeletons, FES, and Biomechanics: Treating Movement Disorders

**Project Role:** PI

**Supporting Agency:** National Institute of Health

**Period of Performance:** 2008-2013

**Level of Funding/ My Portion:** \$3,000,040