Peter Bradley Shull

School of Mechanical Engineering
Shanghai Jiao Tong University
Mechanical Building, 800 Dong Chuan Road, Shanghai 200240, China
Email: pshull@sjtu.edu.cn
Website: www.wearablesystems.org

Education

2008-2012   **Stanford University**, Stanford, California, USA
Ph.D. in Mechanical Engineering
Topics: Real-Time Sensing/Feedback, Human Movement Training, Biomechanics
Advisors: Mark Cutkosky, Scott Delp

2005-2008   **Stanford University**, Stanford, California, USA
M.S. in Mechanical Engineering
Topics: Robotics, Controls, Telerobotics
Advisor: Gunter Niemeyer

2000-2005   **LeTourneau University**, Longview, Texas, USA
B.S. in Mechanical Engineering and Computer Engineering
Advisor: Roger Gonzalez

Positions Held

2022-present   **Professor**, School of Mechanical Engineering
Shanghai Jiao Tong University, Shanghai, China

2016-2021   **Associate Professor**, School of Mechanical Engineering
Shanghai Jiao Tong University, Shanghai, China

2013-2015   **Assistant Professor**, School of Mechanical Engineering
Shanghai Jiao Tong University, Shanghai, China

2012-2013   **Postdoctoral Research Fellow**, Department of Bioengineering
Stanford University, Stanford, California, USA
Advisor: David Camarillo

Research Interests

Our laboratory develops wearable systems to explore principles of human movement and movement modification. We combine robotic, haptic, biomechanics, and machine learning principles to create unique sensors, real-time models, sensor fusion algorithms, and novel feedback devices. We focus on human movement in laboratories, in clinics, and in natural environments such as a home or office. Our target applications are in medicine such as osteoarthritis and stroke and athletics such as basketball and running.

Awards

2018, 2015 Shanghai Jiao Tong University Mechanical Engineering Department Excellent Researcher Award (Top 10%)

2017 Outstanding Researcher Award, United States National Institutes of Health (NIH) National Center for Simulation in Rehabilitation

2017 Shanghai Jiao Tong University Candlestick Excellence in Teaching Award

2014 Shanghai Young Talents Award Recipient

2012 Feature Article in United States National Science Foundation's Online Magazine Science Nation, "Movement Retraining Can Reduce Knee Pain"

2011 Stanford - Tsinghua Visiting Scholar Award Recipient

2007 United States National Science Foundation Graduate Research Fellowship, Honorable Mention

2005 Best Student Presentation, Biorobotics, HSEMB

Publications

Journal Articles (Underlined author indicates student/postdoc of Peter Shull)

1. Tan T, **Shull PB**, Hick JL, Uhlrich SD, Chaudhari AS, "Self-supervised learning improves accuracy and data efficiency for IMU-based ground reaction force estimation," *IEEE Transactions on Biomedical Engineering*, In press, 2024.

2. Lin Y, **Shull PB**, "Novel, soft, water-filled acoustic waveguides for simultaneous tactile force and location sensing," *IEEE Transactions on Industrial Electronics*, In press, 2024.

3. Lin Y, **Shull PB**, Chossat JB, "Design of a wearable real-time hand motion tracking system using an array of soft polymer acoustic waveguides," *Soft Robotics*, In press, 2024.

4. Li J, Zhu K, Li D, Kang P, **Shull PB**, "3D knee and hip angle estimation with reduced wearable IMUs via transfer learning during yoga, golf, swimming, badminton, and dance," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 32: 325-338, 2024.

5. Zhu K, Li J, Li D, Fan B, **Shull PB**, "IMU shoulder angle estimation: Effects of sensor-to-segment misalignment and sensor orientation error," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 31: 4481-4491, 2023.

6. Kang P, Jiang S, **Shull PB**, "Synthetic EMG based on adversarial style transfer can effectively attack biometric-based personal identification models," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 31: 3275-3284, 2023.

7. <u>Sun T</u>, <u>Li D</u>, <u>Fan B</u>, <u>Tan T</u>, **Shull PB**, "Real-time ground reaction force and knee extension moment estimation during drop landings via modular LSTM modeling and wearable IMUs," *IEEE Journal of Biomedical and Health Informatics*, 27(7): 3222-3233, 2023.

8. <u>Jiang S</u>, <u>Strout Z</u>, He B, <u>Peng D</u>, **Shull PB**, Lo BPL, "Dual stream meta learning for road surface classification and riding event detection on shared bikes," *IEEE Transactions on Systems*, Man, and Cybernetics: Systems, 53(11): 7188-7200, 2023.

9. Hafer JF, Vitali R, Gurchiek R, Curtze C, **Shull PB**, Cain SM, "Challenges and advances in the use of wearable sensors for lower extremity biomechanics," *Journal of Biomechanics*, 157: 111714, 2023.

10. <u>Chiasson D</u>, <u>Lin Y</u>, Kok M, **Shull PB**, "Asynchronous hyperbolic UWB source-localization and self-localization for indoor tracking and navigation," *IEEE Internet of Things Journal*, 10(13): 11655-11668, 2023.

11. Charlton JM, <u>Xia H</u>, **Shull PB**, Eng JJ, Li LC, Hunt MA, "Multi-day monitoring of foot progression angles during unsupervised, real-world walking in people with and without knee osteoarthritis," *Clinical Biomechanics*, 105: 105957, 2023.

12. <u>Tan T</u>, Gatti AA, <u>Fan B</u>, Shea KG, Sherman SL, Uhlrich SD, Hicks JL, Delp SL, **Shull PB**, Chaudhari AS, "A scoping review of portable sensing for out-of-lab anterior cruciate ligament injury prevention and rehabilitation," *Nature NPJ Digital Medicine*, 6(1): 46, 2023.

13. <u>Li D</u>, <u>Kang P</u>, <u>Zhu K</u>, <u>Li J</u>, **Shull PB**, "Feasibility of wearable PPG for simultaneous hand gesture and force level classification," *IEEE Sensors Journal*, 23(6): 6008-6017, 2023.

14. <u>Kang P</u>, <u>Li J</u>, Jiang S, **Shull PB**, "Reduce system redundancy and optimize sensor disposition for EMG–IMU multimodal fusion human–machine interfaces with XAI," *IEEE Transactions on Instrumentation and Measurement*, 72: 2500209, 2023.

15. Farhadi F, Ou H, **Shull PB**, Johnson S, "Smart passive gait retraining intervention via pebbles for reducing peak plantar pressure: Short-term results," *Medicine in Novel Technology and Devices*, 19: 100242, 2023.

16. <u>Song X</u>, <u>Van De Ven SS</u>, Liu L, Wouda FJ, <u>Wang H</u>, **Shull PB**, "Activities of daily living-based rehabilitation system for arm and hand motor function retraining after stroke," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 30: 621-631, 2022.

17. <u>Song X</u>, <u>Van De Ven SS</u>, Chen S, <u>Kang P</u>, <u>Gao Q</u>, Jia J, **Shull PB**, "Proposal of a wearable multimodal sensing-based serious games approach for hand movement training after stroke," *Frontiers in Physiology*, 13: 811950, 2022.

18. <u>Tan T</u>, <u>Wang D</u>, **Shull PB**, Halilaj E, "IMU and smartphone camera fusion for knee adduction and knee flexion moment estimation during walking," *IEEE Transactions on Industrial Informatics*, 19(2): 1445-1455, 2022.

19. <u>Tan T</u>, <u>Strout ZA</u>, Cheung RTH, **Shull PB**, "Strike index estimation using a convolutional neural network with a single, shoe-mounted inertial sensor," *Journal of Biomechanics*, 139: 111145, 2022.

20. Rokhmanova N, Kuchenbecker KJ, **Shull PB**, Ferber R, Halilaj E, "Predicting knee adduction moment response to gait retraining with minimal clinical data," *PLOS Computational Biology*, 18(5): e1009500, 2022.

21. <u>Kang P</u>, <u>Li J</u>, Jiang S, **Shull PB**, "A visual variability and visuo-tactile coordination inspired child adaptation mechanism for wearable age group recognition and activity recognition," *Advanced Intelligent Systems*, 5(1): 2200236, 2022.

22. <u>Chiasson D</u>, **Shull PB**, "Ultrawideband ranging in dynamic dense human networks," *IEEE Transactions on Human-Machine Systems*, 52(6): 1327-1337, 2022.

23. <u>Wang H</u>, <u>Kang P</u>, <u>Gao Q</u>, Jiang S, **Shull PB**, "A novel PPG-FMG-ACC wristband for hand gesture recognition," *IEEE Journal of Biomedical and Health Informatics*, 26(10): 5097-5108, 2022.

24. Ma CZH, Bao T, DiCesare CA, Harris I, Chambers A, **Shull PB**, Zheng YP, Cham R, Sienko KH, "Reducing slip risk: A feasibility study of gait training with semi-real-time feedback of foot-floor contact angle," *Sensors*, 22(10): 3641, 2022.

25. <u>Li J</u>, <u>Kang P</u>, <u>Tan T</u>, **Shull PB**, "Transfer learning improves accelerometer-based child activity recognition via subject-independent adult-domain adaption," *IEEE Journal of Biomedical and Health Informatics*, 26(5): 2086-2095, 2022.

26. <u>Fan B</u>, Li Q, <u>Tan T</u>, <u>Kang P</u>, **Shull PB**, "Effects of IMU sensor-to-segment misalignment and orientation error on 3-D joint angle estimation," *IEEE Sensors Journal*, 22(3): 2543-2552, 2022.

27. <u>Kang P</u>, <u>Li J</u>, <u>Fan B</u>, Jiang S, **Shull PB**, "Wrist-worn hand gesture recognition while walking via transfer learning," *IEEE Journal of Biomedical and Health Informatics*, 26(3): 952-961, 2021.

28. **Shull PB**, Xia H, Charlton JM, Hunt MA, "Wearable real-time haptic biofeedback foot progression angle gait modification to assess short-term retention and cognitive demand," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 3(29): 1858-1865, 2021.

29. Jiang S, <u>Kang P</u>, <u>Song X</u>, Lo B, **Shull PB**, "Emerging wearable interfaces and algorithms for hand gesture recognition: A survey," *IEEE Reviews in Biomedical Engineering*, 15: 85-102, 2021.

30. <u>Tan T</u>, <u>Strout ZA</u>, **Shull PB**, "Accurate impact loading rate estimation during running via a subject-independent convolutional neural network model and optimal IMU placement," *IEEE Journal of Biomedical and Health Informatics*, 25(4): 1215-1222, 2021.

31. <u>Chossat JB</u>, **Shull PB**, "Soft acoustic waveguides for strain, deformation, localization and twist measurements," *IEEE Sensors Journal*, 21(1): 222-230, 2021.

32. Wang S, Mo S, Chung RCK, **Shull PB**, Ribeiro DC, Cheung RTH, "How foot progression angle affects knee adduction moment and angular impulse in people with and without medial knee osteoarthritis: a meta-analysis," *Arthritis Care & Research*, 73(12): 1763-1776, 2021.

33. Fan B, Xia H, Xu J, Li Q, **Shull PB**, "IMU-based knee flexion, abduction and internal rotation estimation during drop landing and cutting tasks," *Journal of Biomechanics*, 124: 110549, 2021.

34. Lindsey B, Xu J, Chiasson D, **Shull PB**, Cortes N, "Feasibility of wearable haptic biofeedback training for reducing the knee adduction moment during overground walking," *Journal of Biomechanical Engineering*, 143(4): 044501, 2021.

35. Kang P, Jiang S, **Shull PB**, Lo B, "Feasibility validation on healthy adults of a novel active vibrational sensing based ankle band for ankle flexion angle estimation," *IEEE Open Journal of Engineering in Medicine and Biology*, 2: 314-319, 2021.

36. Li C, Song X, Chen S, Wang C, He J, Zhang Y, Xu S, Yan Z, Jia J, **Shull PB**, "Long-term effectiveness and adoption of a cellphone augmented reality system on patients with stroke: randomized controlled trial," *JMIR Serious Games*, 9(4): e30184, 2021.

37. Xia H, Huang Y, Chen G, Cheng S, Cheung RT, **Shull PB**, "Self-selected running gait modifications reduce acute impact loading, awkwardness, and effort," *Sports Biomechanics*, 1-14, 2021.

38. Tan T, Strout ZA, Xia H, Orban M, **Shull PB**, "Magnetometer-free, IMU-based foot progression angle estimation for real-life walking conditions," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 29: 282-289, 2020.

39. Xia H, Charlton JM, **Shull PB**, Hunt MA, "Portable, automated foot progression angle gait modification via a proof-of-concept haptic feedback-sensorized shoe," *Journal of Biomechanics*, 107: 109789, 2020.

40. Xia H, Chen DKY, Zhu X, **Shull PB**, "Controlled slip energy harvesting while walking," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 2(28): 437-443, 2020.

41. **Shull PB**, Xia H, "Modeling and prediction of wearable energy harvesting sliding shoes for metabolic cost and energy rate outside of the lab," *Sensors*, 20(23): 6915, 2020.

42. Chiasson D, Xu J, **Shull PB**, "Lossless compression of human movement IMU signals," *Sensors*, 20(20): 5926, 2020.

43. Jiang S, Gao Q, Liu H, **Shull PB**, "A novel, co-located EMG-FMG-sensing wearable armband for hand gesture recognition," *Sensors and Actuators A: Physical*, 301: 111738, 2020.

44. Gao Q, Jiang S, **Shull PB**, "Simultaneous hand gesture classification and finger angle estimation via a novel dual-output deep learning model," *Sensors*, 20(10): 2972, 2020.

45. Xu J, Cao F, Zhan S, Ling M, Hu H, **Shull PB**, "Mapping-based dosage of gait modification selection for multi-parameter subject-specific gait retraining," *IEEE Access*, 8: 106354-106363, 2020.

46. Jiang S, Li L, Xu H, Xu J, GU GY, **Shull PB**, "Stretchable e-skin patch for gesture recognition on the back of the hand," *IEEE Transactions on Industrial Electronics*, 67(1): 647-657, 2020.

47. **Shull PB**, Tan T, Culbertson HM, Zhu X, Okamura A, "Resonant frequency skin stretch for wearable haptics," *IEEE Transactions on Haptics*, 12(3): 247-256, 2019.

48. **Shull PB**, Jiang S, Zhu Y, Zhu X, "Hand gesture recognition and finger angle estimation via wrist-worn modified barometric pressure sensing," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 27(4): 724-732, 2019.

49. Tan T, Chiasson DP, Hu H, **Shull PB**, "Influence of IMU position and orientation placement errors on ground reaction force estimation," *Journal of Biomechanics*, 97: 109416, 2019.

50. Chossat JB, Chen DKY, Park YL, **Shull PB**, "Soft wearable skin-stretch device for haptic feedback using twisted and coiled polymer actuators," *IEEE Transactions on Haptics*, 12(4): 521-532, 2019.

51. Song X, Chen S, Jia J, **Shull PB**, "Cellphone-based automated Fugl-Meyer assessment to evaluate upper extremity motor function after stroke," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 27(10): 2186-2195, 2019.

52. Charlton JM, Xia H, **Shull PB**, Hunt MA, "Validity and reliability of a shoe-embedded sensor module for measuring foot progression angle during over-ground walking," *Journal of Biomechanics*, 89: 123-127, 2019.

53. Bao T, Su L, Kinnaird C, Kabeto M, **Shull PB**, Sienko K, "Vibrotactile display design: Quantifying the importance of age and various factors on reaction times," *PloS one*, 14(8): e0219737, 2019.

54. Zhang JH, Chan ZY, Au IP, An WW, **Shull PB**, Cheung RT, "Transfer learning effects of biofeedback running retraining in untrained conditions," *Medicine and Science in Sports and Exercise*, 51(9): 1904-1908, 2019.

55. Maglott J, Chiasson D, **Shull PB**, "Influence of skill level on predicting the success of one's own basketball free throws," *PloS one*, 14(3): e0214074, 2019.

56. Huang Y, Xia H, Chen G, Cheng S, Cheung RTH, **Shull PB**, "Foot strike pattern, step rate, and trunk posture combined gait modifications to reduce impact loading during running," *Journal of Biomechanics*, 86: 102-109, 2019.

57. Jiang S, Lv B, Guo W, Zhang C, Wang H, Sheng X, **Shull PB**, "Feasibility of wrist-worn, real-time hand and surface gesture recognition via sEMG and IMU sensing," *IEEE Transactions on Industrial Informatics*, 14(8): 3376-3385, 2018.

58. Wang J, Xu J, **Shull PB**, "Vertical jump height estimation algorithm based on take-off and landing identification via foot-worn inertial sensing," *Journal of Biomechanical Engineering*, 140(3): 034502, 2018.

59. Uhlrich SD, Silder A, Beaupre GS, **Shull PB**, Delp SL, "Subject-specific toe-in or toe-out gait modifications reduce the larger knee adduction moment peak more than a non-personalized approach," *Journal of Biomechanics*, 66: 103-110, 2018.

60. Li L, Jiang S, **Shull PB**, Gu GY, "SkinGest: artificial skin for gesture recognition via filmy stretchable strain sensors," *Advanced Robotics*, 1-10, 2018.

61. Xu J, Bao T, Lee UH, Kinnaird C, Carender W, Huang Y, Sienko KH, **Shull PB**, "Configurable, wearable sensing and vibrotactile feedback system for real-time postural balance and gait training: proof-of-concept," *Journal of NeuroEngineering and Rehabilitation*, 14(1): 102, 2017.

62. Xia H, Xu J, Wang J, Hunt MA, **Shull PB**, "Validation of a smart shoe for estimating foot progression angle during walking gait," *Journal of Biomechanics*, 61: 193-198, 2017.

63. **Shull PB**, Zhu X, Cutkosky MR, "Continuous movement tracking performance to predictable and unpredictable tasks with vibrotactile feedback," *IEEE Transactions on Haptics*, 10(4): 466-475, 2017.

64. Lin S, Xu J, Zhi X, Chen D, Miao J, **Shull PB**, Cui D, "Design and fabrication of a stretchable circuit board for wireless posture measurement," *IEEE Electron Device Letters*, 38(3): 399-402, 2017.

65. **Shull PB**, Xu J, Yu B, Zhu X, "Magneto-gyro wearable sensor algorithm for trunk sway estimation during walking and running gait," *IEEE Sensors Journal*, 17(2): 480-486, 2017.

66. Huang Y, Jirattigalachote W, Cutkosky MR, Zhu X, **Shull PB**, "Novel foot progression angle algorithm estimation via foot-worn, magneto-inertial sensing," *IEEE Transactions on Biomedical Engineering*, 63(11): 2278-2285, 2016.

67. Huang Y, Xu J, Yu B, **Shull PB**, "Validity of Fitbit, Jawbone UP, Nike+ and other wearable devices for level and stair walking," *Gait & Posture*, 48: 36-41, 2016.

68. Zhang D, Xu F, Xu H, **Shull PB**, Zhu X, "Quantifying different tactile sensations evoked by cutaneous electrical stimulation using electroencephalography features," *International Journal of Neural Systems*, 26: 1650006, 2016.

69. **Shull PB**, Huang Y, Schlotman T, Reinbolt JA, "Muscle force modification strategies are not consistent for gait retraining to reduce the knee adduction moment in individuals with knee osteoarthritis," *Journal of Biomechanics*, 48: 3163-3169, 2015.

70. Hernandez F, **Shull PB**, Camarillo DB, "Evaluation of a laboratory model of human head impact biomechanics," *Journal of Biomechanics*, 48: 3469-3477, 2015.

71. **Shull PB**, Damian DD, "Haptic wearables as sensory replacement, sensory augmentation and trainer–a review," *Journal of Neuroengineering and Rehabilitation*, 12(1), 59, 2015.

72. Zhang D, Xu H, **Shull PB**, Liu J, Zhu X, "Somatotopical feedback versus non-somatotopical feedback for phantom digit sensation on amputees using electrotactile stimulation," *Journal of Neuroengineering and Rehabilitation*, 12(1), 44, 2015.

73. **Shull PB**, Jirattigalachote W, Hunt MA, Cutkosky MR, Delp SL, "Quantified self and human movement: A review on the clinical impact of wearable sensing and feedback for gait analysis and intervention," *Gait & Posture*, 40: 11-19, 2014.

74. Sui J, **Shull PB**, Ji L, "Pilot study of vibration stimulation on neurological rehabilitation," *Bio-medical Materials and Engineering*, 24(6): 2593-2601, 2014.

75. **Shull PB**, Silder A, Shultz R, Besier TF, Delp SL, Cutkosky MR, "Six-week gait retraining program reduces knee adduction moment, reduces pain, and improves function for individuals with medial compartment knee osteoarthritis," *Journal of Orthopaedic Research,* 31(7): 1020-1025, 2013.

76. **Shull PB**, Shultz R, Silder A, Besier TF, Cutkosky MR, Delp SL, "Toe-in gait reduces the first peak in the knee adduction moment during walking in knee osteoarthritis patients," *Journal of Biomechanics*, 46: 122-128, 2013.

77. Camarillo DB, **Shull PB**, Mattson J, Shultz R, Garza D, "An instrumented mouthguard for measuring linear and angular head impact kinematics in American football," *Annals of Biomedical Engineering,* 41(9): 1939-1949, 2013.

78. Tenforde AS, **Shull PB**, Fredericson M, "Neuromuscular prehabilitation to prevent osteoarthritis after a traumatic joint injury," *Physical Medicine and Rehabilitation,* 4: S141-144, 2012.

79. **Shull PB**, Lurie K, Cutkosky MR, Besier TF, "Training multi-parameter gaits to reduce the knee adduction moment with data-driven models and haptic feedback," *Journal of Biomechanics*, 44(8): 1605-1609, 2011.

80. Wheeler JW, **Shull PB**, Besier TF, "Real-time knee adduction moment feedback for gait retraining through visual and tactile displays," *Journal of Biomechanical Engineering,* 133(4): 041007, 2011.

81. Bark K, Wheeler JW, **Shull PB**, Savall J, Cutkosky MR, "Rotational skin stretch feedback: a wearable haptic display for motion," *IEEE Transactions on Haptics*, 3(3): 166-176, 2010.

82. **Shull PB**, Gonzalez RV, "Real-time haptic-teleoperated robotic system for motor control analysis," *Journal of Neuroscience Methods*, 151(2): 194-199, 2006.

Conference Articles (<u>Underlined author</u> indicates student/postdoc of Peter Shull)

1. <u>Wang H</u>, <u>Li D</u>, Liang K, **Shull PB**, "Subject-independent ankle joint power estimation with two IMUs during flat and inclined walking," *IEEE International Conference on Body Sensor Networks (BSN)*, 2023.

2. <u>Kang P</u>, <u>Zhu K</u>, Jiang S, He B, **Shull PB**, "HBOD: A novel dataset with synchronized hand, body, and object manipulation data for human-robot interaction," *IEEE International Conference on Body Sensor Networks (BSN)*, 2023.

3. <u>Lin Y</u>, <u>Alemu M</u>, **Shull PB**, "Investigation of soft acoustic waveguide dispersion for wearable strain sensing in human motion monitoring," *International Conference on Intelligent Robotics and Applications*, pp. 238-249, 2023.

4. <u>Alemu M</u>, <u>Lin Y</u>, **Shull PB**, "Design and fabrication of an artificial skin integrated with soft ultrasonic waveguides for finger joint motion detection," *International Conference on Intelligent Robotics and Applications*, pp. 206-218, 2023.

5. Lin Y, Chiasson D, **Shull PB**, "Wearable water-filled soft transparent pressure sensor based on acoustic guided waves," *IEEE International Ultrasonics Symposium (IUS)*, pp. 1-4, 2022.

6. Xia H, Kwon J, Pathak P, Ahn J, **Shull PB**, Park YL, "Design of a multi-functional soft ankle exoskeleton for foot-drop prevention, propulsion assistance, and inversion/eversion stabilization," *IEEE RAS/EMBS International Conference for Biomedical Robotics and Biomechatronics (BioRob)*, pp. 118-123, 2020.

7. Song X, Ding L, Zhao J, Jia J, **Shull PB**, "Cellphone augmented reality game-based rehabilitation for improving motor function and mental state after stroke," *IEEE International Conference on Wearable and Implantable Body Sensor Networks (BSN)*, 2019.

8. Maglott J, **Shull PB**, "Wearable occlusion device for assessing cognitive basketball shooting performance between males and females," *Proceedings of the International Conference on Industrial Control Network and System Engineering Research*, pp. 37-41, 2019.

9. Peng D, Strout Z, Jiang S, **Shull PB**, "A road condition classifier via lock embedded IMU on dock-less shared bikes," *Proceedings of the International Conference on Industrial Control Network and System Engineering Research*, pp. 32-36, 2019.

10. Chen DKY, Chossat JB, **Shull PB**, "HaptiVec: Presenting haptic feedback vectors in handheld controllers using embedded tactile pin arrays," *ACM CHI Conference on Human Factors in Computing Systems*, 2019.

11. **Shull PB**, Xia H, "Energy harvesting modeling and prediction during walking gait for a sliding shoe," *23rd IEEE International Conference on Digital Signal Processing (DSP)*, 2018.

12. Zhu Y, Jiang S, **Shull PB**, "Wrist-worn hand gesture recognition based on barometric pressure sensing," *IEEE International Conference on Wearable and Implantable Body Sensor Networks (BSN)*, pp. 181-184, 2018.

13. Xia H**, Shull PB**, "Preliminary testing of an angled sliding shoe for potential human energy harvesting applications," *2nd International Conference on Robotics and Automation Sciences*, pp. 147-150, 2018.

14. Xu J, Lee UH, Bao T, Huang Y, Sienko KH, **Shull PB**, "Wearable sensing and haptic feedback research platform for gait retraining," *IEEE International Conference on Wearable and Implantable Body Sensor Networks (BSN)*, pp. 125-128, 2017.

15. Maglott JC, Xu J, **Shull PB**, "Differences in arm motion timing characteristics for basketball free throw and jump shooting via a body-worn sensorized sleeve," *IEEE International Conference on Wearable and Implantable Body Sensor Networks (BSN)*, pp. 31-34, 2017.

16. Ling Li, Jiang S, Tao Y, **Shull PB**, Gu GY, "Fabrication and testing of a filmy "feelingless" stretchable strain sensor," *IEEE/SICE International Symposium on System Integration (SII)*, pp. 362-367, 2017.

17. Jiang S, Bo Lv, Sheng X, Zhang C, Wang H, **Shull PB**, "Development of a real-time gesture recognition wristband based on sEMG and IMU sensing," *IEEE International Conference on Robotics and Biomimetics*, 2016.

18. Chen DKY, <u>Xu J</u>, **Shull PB**, Besier TF, "Tactile apparent movement as a modality for lower limb haptic feedback," *International Conference on Human Haptic Sensing and Touch Enabled Computer Applications*, pp. 373-383, 2016.

19. <u>Yu B</u>, Bao T, Zhang D, Carender W, Sienko KH, **Shull PB**, "Determining inertial measurement unit placement for estimating human trunk sway while standing, walking and running," *37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society EMBC*, 2015.

20. <u>Huang Y</u>, Guo W, Liu J, He J, Xia H, Sheng X, Wang H, Feng X, **Shull PB**, "Preliminary testing on a hand gesture recognition wristband based on EMG and inertial sensor fusion," *8th International Conference on Intelligent Robotics and Applications*, 2015.

21. Zhang B, **Shull PB**, Zhang D, "A simulation study on nerve block by electrical stimulation with high frequency," *9th International Convention on Rehabilitation Engineering & Assistive Technology*, 2015.

22. **Shull PB**, Jirattigalachote W, Zhu X, "An overview of wearable sensing and wearable feedback for gait retraining," *International Conference on Intelligent Robotics and Applications*, pp. 434-443, 2013.

23. Jirattigalachote W, **Shull PB**, Cutkosky MR, "Virtual pebble: a haptic state display for pedestrians," *IEEE Ro-Man Symposium*, pp. 401-406, 2011.

24. Lurie KL, **Shull PB**, Nesbitt KF, Cutkosky MR, "Informing haptic feedback design for gait retraining," *IEEE World Haptics*, pp. 19-24, 2011.

25. Rantala J, Myllymaa K, Raisamo R, Lylykangas J, Surakka V, **Shull PB**, Cutkosky MR, "Presenting spatial tactile messages with a hand-held device," *IEEE World Haptics*, pp. 101-106, 2011.

26. **Shull PB**, Lurie KL, Shin M, Besier TF, Cutkosky MR, "Haptic gait retraining for knee osteoarthritis treatment," *IEEE Haptics Symposium*, pp. 409-416, 2010.

27. **Shull PB**, Bark K, Cutkosky MR, "Skin nonlinearities and their effect on user perception for rotational skin stretch," *IEEE Haptics Symposium*, pp. 77-82, 2010.

28. Lurie KL, Manual J, **Shull PB**, "Haptic motion training: exploring learning environments for a portable gait retraining system," *IEEE International Symposium on Haptic Audio-Visual Environments and Games*, pp. 1-6, 2010.

29. **Shull PB**, Niemeyer G, "Open-loop bilateral teleoperation for stable force tracking," *IEEE/RSJ International Conference on Intelligent Robots and Systems*, pp. 5121-5126, 2009.

30. **Shull PB**, Niemeyer G," Force and position scaling limits for stability in force reflecting teleoperation," *ASME Dynamic Systems and Control Conference*, pp. 607-614, 2008.

31. Hart JS, **Shull PB**, Gentry D, Niemeyer G, Roderick S, Akin D, "Wave-variable based force feedback for a space-qualified telerobot," *ASME Dynamic Systems and Control Conference*, 303-310, 2008.

32. **Shull PB**, Niemeyer G, "Experiments in local force feedback for high-inertia, high-friction telerobotic systems," *ASME International Mechanical Engineering Congress and Exposition*, pp. 1241-1246, 2007.

33. Awwal AAS, Ferguson WS, **Shull PB**, "Best angle to orient two intersecting lines," *SPIE*, pp. 63100-63111, 2006.

Conference Abstracts (<u>Underlined author</u> indicates student/postdoc of Peter Shull)

1. <u>Zhu K</u>, <u>Li J</u>, **Shull PB**, "IMU-based 3D shoulder and elbow joint angle estimation during badminton, golf, dance, yoga, and swimming," *American Society of Biomechanics (ASB) Annual Meeting*, 2023.

2. <u>Li J</u>, <u>Zhu K</u>, <u>Kang P</u>, **Shull PB**, "Activity recognition improves lower-limb kinematics prediction using a reduced IMU sensor configuration," *American Society of Biomechanics (ASB) Annual Meeting*, 2023.

3. Tan T, **Shull PB**, Chaudhari AS, "Improving data efficiency and accuracy of IMU-driven biomechanical assessment via self-supervised learning," *American Society of Biomechanics (ASB) Annual Meeting*, 2023.

4. Tan T, Gatti AA, Fan B, Uhlrich S, Hicks J, Delp S, **Shull PB**, Chaudhari AS, Sherman S, Shea KG, "Towards out-of-gait-lab anterior cruciate ligament injury prevention and personalized rehabilitation assessment: A review of portable sensing approaches," *Pediatric Orthopaedic Society of North America (POSNA) Annual Meeting*, 2023.

5. **Shull PB**, <u>Strout Z</u>, <u>Tan T</u>, <u>Chiasson D</u>, Cheung RTH, "Foot strike index estimation via a shoe-mounted IMU using a subject-independent convolutional neural network," *World Congress of Biomechanics (WCB)*, 2022.

6. <u>Fan B</u>, **Shull PB**, Influence of IMU sensor-to-segment alignment and orientation errors on 3D knee joint angle estimation," *World Congress of Biomechanics (WCB)*, 2022.

7. Lindsey B, <u>Chen D</u>, **Shull PB**, Speed adjusted increased step width reduces internal peak knee abduction moment during overground walking," *World Congress of Biomechanics (WCB)*, 2022.

8. Charlton JM, <u>Xia H</u>, **Shull PB**, Hunt MA, "Foot progression angle is consistent in real-world, unsupervised walking while capturing more variability than traditional laboratory settings in people with knee osteoarthritis," *OARSI Annual Meeting*, 30: S134-S135, 2022.

9. Poretti K, **Shull PB**, Cortes N, Lindsey B, "Effects of single and multi-parameter gait modifications on non-modified limb kinetics and kinematics," *Medicine & Science in Sports & Exercise Meeting*, 54 (9S), 394, 2022.

10. <u>Tan T</u>, <u>Wang D</u>, **Shull PB**, Haliliaj E, "IMU-camera fusion for estimating knee adduction and flexion moments," *American Society of Biomechanics (ASB) Annual Meeting*, 2021.

11. <u>Jiang S</u>, Chen X, **Shull PB**, Lo BPL, "Fall detection sensing and fall prevention intervention based on active sensing and stochastic resonance," *Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, 2020.

12. <u>Chossat JB</u>, **Shull PB**, "Soft polymeric acoustic waveguides for tactile sensing: Strain, compression and contact localization," *IEEE International Conference on Soft Robotics (RoboSoft)*, 2020.

13. <u>Fan B</u>, Li Q, **Shull PB**, "3D knee joint angle estimation during drop landing using inertial sensors: Towards ACL injury risk assessment," *International Society of Biomechanics (ISB) Conference*, 2020.

14. <u>Tan T</u>, <u>Strout ZA</u>, **Shull PB**, "Magnetometer-free inertial-sensor-based foot progression angle estimation," *International Society of Biomechanics (ISB) Conference*, 2020.

15. <u>Chiasson DP</u>, <u>Xu J</u>, **Shull PB**, "An investigation of human movement IMU data compression methods," *International Society of Biomechanics (ISB) Conference*, 2020.

16. <u>Rokhmanova N</u>, **Shull PB**, Kuchenbecker KJ, Halilaj E, "Subject-specific biofeedback for gait retraining outside of the lab," *Dynamic Walking Conference Annual Meeting*, 2020.

17. <u>Xu J</u>, <u>Chiasson DP</u>, <u>Cao F</u>, Hu H, **Shull PB**, "A real-time subject-specific gait retraining dosage selection method for knee osteoarthritis," *International Society of Biomechanics (ISB) Conference*, 2019.

18. **Shull PB**, <u>Xia H</u>, <u>Huang Y</u>, Chen G, Cheng S, Chueng RT, "Combined gait modifications for runners to reduce impact loading," *International Society of Biomechanics (ISB) Conference*, 2019.

19. Charlton JM, <u>Xia H</u>, **Shull PB**, Hunt MA, "The validity and day-to-day reliability of a shoe-embedded sensor module for estimating foot progression angle during over-ground walking," *International Society of Biomechanics (ISB) Conference*, 2019.

20. <u>Xu J</u>, <u>Cao F</u>, <u>Chiasson DP</u>, **Shull PB**, "Python-integrated wearable research platform for fast software prototyping in gait retraining applications," *IEEE International Conference on Wearable and Implantable Body Sensor Networks (BSN)*, 2019.

21. <u>Xia H</u>**,** Charlton JM, Hunt MA, **Shull PB**, "Preliminary test of a smart shoe for training foot progression angle during walking," *Osteoarthritis Research Society International (OARSI) World Congress*, 27: S64-65, 2019.

22. Ma CZH, Bao T, Le VC, Chambers A, **Shull PB**, Zheng YP, Cham R, Sienko KH, "A feasibility study for gait training with foot-floor contact angle feedback," *International Society of Posture & Gait Research (ISPGR) World Congress*, 2019.

23. <u>Huang Y</u>, <u>Song X</u>, <u>Tan T</u>, **Shull PB**, "Motion tracking based on embedded visual-inertial coupled SLAM for upper-limb movement training," *IEEE International Conference on Wearable and Implantable Body Sensor Networks (BSN)*, 2018.

24. Charlton JM, Xia H, Hunt MA, **Shull PB**, "Over-ground walking validation of a smart shoe for estimating foot progression angle," *Osteoarthritis Research Society International (OARSI) World Congress*, 26: S394-S395, 2018.

25. Xia H, Xu J, Wang J, Hunt MA, **Shull PB**, "A sensorized smart shoe for estimating foot progression angle while walking," *International Society of Biomechanics (ISB) Conference*, 2017.

26. Uhlrich SD, Silder A, Beaupre GS, **Shull PB**, Delp SL, "Subject-specific foot progression angle modifications to reduce the knee adduction moment," *International Society of Biomechanics (ISB) Conference*, 2017.

27. Xia H, Xu J, Wang J, Hunt MA, **Shull PB**, "Development of a smart shoe for estimating foot progression angle during walking gait," *Dynamic Walking Conference Annual Meeting*, 2016.

28. Schlotman T, **Shull PB**, Reinbolt JA, "Decreasing knee joint contact loads via toe-in gait for patients with knee osteoarthritis," *American Society of Biomechanics Annual Meeting*, 2016.

29. Bao T, Su L, Kinnaird C, **Shull PB**, Sienko KH, "The effects of tactor location on vibrotactile stimulation reaction times in healthy adults," *37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, 2015.

30. Hernandez F, **Shull PB**, Camarillo DB, "Limitations of standard twin-wire drop testing for modeling concussion kinematics in football," *Biomedical Engineering Society Annual Meeting*, 2015.

31. Chen DKY, Xu J, **Shull PB**, Anderson I, Besier TF, "Lower extremity tactile apparent movement perception during standing and walking," *IEEE/RSJ International Conference on Intelligent Robots and Systems*, 2015.

32. **Shull PB**, Jirattigalachote W, Hunt MA, Cutkosky MR, Delp SL, "An overview of wearable sensing and feedback for gait analysis and intervention," *World Congress of Biomechanics*, 2014.

33. Schlotman TE, **Shull PB**, Reinbolt JA, "Analysis of toe-in gati modification for patients with knee osteoarthritis," *Biomedical Engineering Society Annual Meeting*, 2014.

34. Hernandez F, **Shull PB**, Cam B, Wu L, Shultz R, Garza D, Camarillo DB, "Comparing in vivo head impact kinematics from American football with laboratory drop and linear impactors," *ASME Summer Bioengineering Conference*, 2013.

35. Camarillo DB, Mattson J, Flynn M, Yang S, **Shull PB**, Shultz R, Matheson G, Garza D, "Head contacts in collegiate football measured with an instrumented mouthguard," *4th International Conference on Concussion in Sport*, 2013.

36. **Shull PB**, Silder A, Shultz R, Besier TF, Delp SL, Cutkosky MR, "Six-week gait retraining program for knee osteoarthritis patients: learning retention and symptom changes," *American Society of Biomechanics Annual Meeting*, 2012.

37. **Shull PB**, Shultz R, Silder A, Besier TF, Cutkosky MR, Delp SL, "Toe-in gait reduces the first peak in the knee adduction moment during walking in knee osteoarthritis patients," *American Society of Biomechanics Annual Meeting*, 2012.

38. **Shull PB**, Wheeler JW, Lurie K, Cutkosky MR, Besier TF, "Implicit and explicit real-time feedback for reducing the knee adduction moment during gait retraining," *Orthopaedic Research Society Annual Meeting*, 2011.

39. **Shull PB**, Gonzalez RV, "A haptic robotic assessment device to study human learning and adaptation," *22nd Annual Conference of the Houston Society for Engineering in Medicine and Biology*, 2005.

40. **Shull PB**, Gonzalez RV, "Bimanual motor control: biological and robotic system learning via simultaneous movement requirements," *20th Congress of the International Society of Biomechanics*, 2005.

Technical Presentations

1. National Natural Science Foundation of China 8th Advanced Design and Manufacturing Forum, "Wrist-Worn Hand Gesture Recognition," Nanjing, China, October 22, 2023.

2. KIST-UST Global Mentor Program, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Korea (online), August 29, 2023.

3. Technion Israel Institute of Technology, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Haifa, Israel, July 27, 2023.

4. Tel-Aviv Sourasky Medical Center, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Tel-Aviv, Israel, June 27, 2023.

5. La Trobe University, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Melbourne, Australia, June 7, 2023.

6. CLEAR Group UNC/NC State, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Chapel Hill, North Carolina, USA (online), June 2, 2023.

7. Goertek, "Wrist-Worn Hand Gesture Recognition," Beijing, China (online), May 31, 2023.

8. China Micro and Nanotechnology Society Flexible Electronics Technology and Application Innovation Forum, "Wrist-Worn Hand Gesture Recognition," Suzhou, China, May 21, 2023.

9. ByteDance, "Wearable Systems Lab," Seattle, Washington, USA and Beijing, China (online), April 11, 2023.

10. China Micro and Nanotechnology Society Flexible Electronics Technology and Application Innovation Forum, "Wrist-Worn Hand Gesture Recognition," Hangzhou, China (online), November 6, 2022.

11. World Congress of Biomechanics, Podium Presentation, "Foot Strike Index Estimation via a Shoe-Mounted IMU Using a Convolutional Neural Network," Taipei, Taiwan (online), July 7, 2022.

12. ByteDance, "Wrist-Worn Hand Gesture Recognition," Seattle, Washington, USA and Beijing, China (online), July 6, 2022.

13. Queen's University Belfast, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Belfast, Northern Ireland, UK (online), March 23, 2022.

14. Beihang University, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Beijing, China, June 3, 2021.

15. Keystone academy, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Beijing, China, May 4, 2021.

16. Meta Reality Labs, "Wrist-Worn Hand Gesture Recognition," Seattle, Washington, USA (online), April 8, 2021.

17. China National Rowing Team, Invited Seminar, "Wearable Systems Lab," Qiandao Lake, Zhejiang, China, March 4, 2021.

18. Dalian University, Invited Seminar, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Dalian, Liaoning, China, September 25, 2020.

19. Shanghai International Geriatric Rehabilitation Forum (IGF), Invited Presentation, "Cellphone Augmented Reality Game-based Rehabilitation for Improving Motor Function and Mental State after Stroke," Shanghai, China, August 23, 2020.

20. China Rehabilitation Technology and Assistive Appliance Innovation Conference (IRHE), Invited Podium Presentation, "Cellphone AR Serious Games for Improving Motor Function and Mental State after Stroke," Qinhuangdao, Hebei, China, November 20, 2019.

21. The 2nd International Conference on Image, Video Processing and Artificial Intelligence, Invited Keynote Presentation, "Artificial Intelligence for Wearable Hand Gesture Recognition," Shanghai, China, August 25, 2019.

22. Shanghai International Conference on Biomechanics in Human Movement and Clinical Translation, Invited Podium Presentation, "Wearable Systems for Gait and Posture Assessment and Training," Shanghai, China, June 29, 2019.

23. Yanshan University, Invited Seminar, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Qinhuangdao, Hebei, China, June 21, 2019.

24. IEEE International Conference on Body Sensor Networks (BSN), Podium Presentation, "Cellphone Augmented Reality Game-based Rehabilitation for Improving Motor Function and Mental State after Stroke," Chicago, IL, USA, May 22, 2019.

25. Hebei University of Technology, Invited Seminar, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Tianjin, China, October 27, 2018.

26. Researcher Links Workshop on Mental Health Technologies in China and the UK, Invited Podium Presentation, "Wearable Systems for Medical Applications," Jinan, Shandong, China, September 8, 2018.

27. Queen Mary University of London, Invited Seminar, "Wearable Systems for Biomedical Applications and Human Computer Interaction," London, United Kingdom, July 24, 2018.

28. Shenzhen University, Invited Seminar, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Shenzhen, Guangzhou, China, April 13, 2018.

29. Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, Invited Seminar, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Shenzhen, Guangzhou, China, April 12, 2018.

30. 17th International Conference on Control, Automation and Systems (ICCAS 2017), Invited Podium Presentation for special session on soft robotics, "Smart Wearables for Gesture Recognition and Gait Training," Jeju, Korea, October 20, 2017.

31. 2nd National Medical Intelligence Congress, Invited Keynote Presentation, "Wearable Systems for Medical Applications," Chengdu, Sichuan, China, September 17, 2017.

32. Shanghai 6th People's Hospital Orthopaedic Biomechanics Laboratory, Invited Seminar, "Wearable Systems for Treating Knee Osteoarthritis and Balance Disorders," Shanghai, China, September 13, 2017

33. IEEE International Conference on Body Sensor Networks (BSN), Podium Presentation, "Wearable Sensing and Haptic Feedback Research Platform for Gait Retraining," Eindhoven, Netherlands, May 11, 2017.

34. Stanford University Neuromuscular Biomechanics Laboratory, Invited Seminar, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Stanford, California, USA, April 25, 2017.

35. Stanford University Charm Laboratory, Invited Seminar, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Stanford, California, USA, April 14, 2017.

36. Shanghai University of Engineering and Science, Invited Seminar, "Wearable Technology," Shanghai City, Shanghai, China, November 23, 2016.

37. Ningbo University, Invited Seminar, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Ningbo, Zhejiang, China, September 27, 2016.

38. Zhejiang University State Key Laboratory of Fluid Power and Electromechical Systems, Invited Seminar, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Hangzhou, Zhejiang, China, April 7, 2016.

39. Zhejiang University Electrical Engineering Dept, Invited Seminar, "Wearable Systems for Biomedical Applications and Human Computer Interaction," Hangzhou, Zhejiang, China, April 6, 2016.

40. ETH-Zurich Wearable Computing Laboratory, Invited Seminar, "Wearable Systems for Human Movement," Zurich, Switzerland, August 24, 2015.

41. University of Michigan Neuromechanics Group, Invited Seminar, "Wearable Sensing and Feedback Systems for Human Movement," Ann Arbor, Michigan, June 1, 2015.

42. Xi'an Jiao Tong University, Invited Seminar, "Gait Retraining and Wearable Systems for Knee Osteoarthritis," Xi'an, Shaanxi, China, October 31, 2014.

43. World Congress of Biomechanics, Podium Presentation, "An Overview of Wearable Sensing and Feedback for Gait Analysis and Intervention," Boston, Massachusetts, July 10, 2014.

44. Conference on Rehabilitation Medical Engineering, Invited Seminar, "Gait Retraining to Reduce Pain and Medial Compartment Loading for Knee Osteoarthritis," Shanghai, China, May 26, 2014.

45. International Conference on Intelligent Robotics and Applications, Podium Presentation, "An Overview of Wearable Sensing and Wearable Feedback for Gait Retraining," Busan, Korea, September 26, 2013.

46. Department of Physical Therapy and Rehabilitation at the University of California San Francisco, Invited Seminar, "Gait Retraining to Reduce Pain and Medial Compartment Loading for Knee Osteoarthritis," San Francisco, California, September 18, 2013.

47. Neuromuscular Biomechanics Laboratory at the University of Delaware, Invited Seminar, "Gait Retraining to Reduce Pain and Medial Compartment Loading for Knee Osteoarthritis," Newark, Delaware, May 13, 2013.

48. GRASP Laboratory at the University of Pennsylvania, Invited Seminar, "Wearable Haptics for Clinical Applications," Philadelphia, Pennsylvania, May 10, 2013.

49. American Society of Biomechanics Annual Meeting, Podium Presentation, "Toe-in Gait Reduces the First Peak in the Knee Adduction Moment During Walking in Knee Osteoarthritis Patients," Gainesville, Florida, August 17, 2012.

50. Delsys Symposium, Invited Seminar, "EMG-Controlled Robotics to Assess Human Motor Control and Learning," Shanghai, China, May 7, 2012.

51. Mechanical Engineering Department at Shanghai Jiao Tong University, Invited Seminar, "Haptic Feedback for Human Movement Training and Rehabilitation," Shanghai, China, May 4, 2012.

52. University of Science and Technology of China, Invited Seminar, "Haptic Feedback for Human Movement Training and Rehabilitation," Hefei, China, May 2, 2012.

53. Camarillo Laboratory at Stanford University, Invited Seminar, "Wearable Haptic Feedback for Human Movement Training and Rehabilitation," Stanford, California, March 5, 2012.

54. Collaborative Haptics and Robotics in Medicine Laboratory at Stanford University, Invited Seminar, "Wearable Haptic Feedback for Stroke Rehabilitation," Stanford, California, August 17, 2011.

55. Shanghai Jiao Tong University School of Mechanical Engineering, Invited Seminar, "Wearable Haptic Feedback for Human Movement Training and Rehabilitation," Shanghai, China, July 22, 2011.

56. Med-X Research Institute of Shanghai Jiao Tong University, Invited Seminar, "Wearable Haptic Feedback for Human Movement Training and Rehabilitation," Shanghai, China, July 21, 2011.

57. University of Michigan-Shanghai Jiao Tong University Joint Institute, Invited Seminar, "Human Motion Training through Wearable Feedback for Medical Applications," Shanghai, China, June 28, 2011.

58. Biomedical Manufacturing and Life Quality Engineering Institute at Shanghai Jiao Tong University, Invited Seminar, "Human Motion Training through Wearable Feedback for Medical Applications," Shanghai, China, June 27, 2011.

59. Department of Precision Instruments and Mechanology at Tsinghua University, "Movement Retraining through Haptic Feedback," Beijing, China, May 22, 2011.

60. IEEE Haptics Symposium, Paper presentation, "Haptic Gait Retraining for Knee Osteoarthritis Treatment," Waltham, Massachusetts, March 26, 2010.

61. Neuromuscular Biomechanics Laboratory at Stanford University, Invited Seminar, "Real-time Haptic Gait Retraining to Alter Knee-Joint Loading," Stanford, California, December 11, 2009.

62. Biomotion Laboratory at Stanford University, Invited Seminar, "Real-time Haptic Gait Retraining to Alter Knee-Joint Loading," Stanford, California, October 20, 2009.

63. Department of Computer Science, School of Information Sciences at University of Tampere, Invited Seminar, "Haptics for Movement Retraining in Medical Applications," Tampere, Finland, September 18, 2009.

64. ASME Dynamic Systems and Control Conference, Paper presentation, "Stability as a Gateway for Improving Large-slave Teleoperation," Ann Arbor, Michigan, October 20, 2008.

65. ASME Dynamic Systems and Control Conference, Paper presentation, "Wave-variable Control of a Space-qualified Telerobot," Ann Arbor, Michigan, October 20, 2008.

66. ASME International Mechanical Engineering Congress and Exposition, Paper presentation, "Experiments in Local Force Feedback for High-Inertia/Friction Telerobotic Systems," Seattle, Washington, November 12, 2007.

67. Houston Society for Engineering in Medicine and Biology, Paper presentation, "A Haptic, Robotic, Assessment Device to Study Human Learning and Adaptation," Houston, Texas, February 10, 2005.

68. Center for Biomedical Engineering Research, Department of Mechanical Engineering at University of Delaware, Invited Seminar, "The Intelligent Prosthetic Arm," Newark, Delaware, July 15, 2004.

Grants

Current Projects

1. Title: Wearable Soft Acoustic Waveguides for Hand Gesture Recognition in Daily Activities
   Role: PI
   Dates: 2023.01.01 – 2024.12.31
   Source: National Natural Science Foundation of China – Major Project: RFIS-II
   Amount: RMB 800,000

2. Title: Soft Axial and Shear Force Sensing Wearable Wristband Based on 3D Hall Effect Sensor Matrices for Human Computer Interaction
   Role: PI
   Dates: 2023.09.01 – 2024.08.31
   Source: ByteDance
   Amount: RMB 550,000

3. Title: Intelligent Step Counting for Smart Wearable Devices
   Role: PI
   Dates: 2024.01.08 – 2025.01.07
   Source: Love and Protect Technology Company
   Amount: RMB 60,000

Past Projects

4. Title: Wearable Algorithms for Musculoskeletal Rehabilitation
   Role: PI
   Dates: 2022.09.26 – 2024.01.17
   Source: TensorHealth
   Amount: RMB 500,000

5. Title: Multi-IMU Fusion for Whole Body Movement Detection
   Role: PI
   Dates: 2021.08.31 – 2023.03.30
   Source: Huawei Research
   Amount: RMB 618,000

6. Title: Research on Gait Retraining via Wearable Body Sensing Networks after Total Knee Arthroplasty
   Role: PI
   Dates: 2019.01.01 – 2022.12.31
   Source: National Natural Science Foundation of China – Major Project
   Amount: RMB 600,000

7. Title: Exploring Wearable Solutions for Functional Evaluation and Motor Rehabilitation in Stroke Patients
   Role: PI
   Dates: 2018.11.27 – 2022.11.26

Source: Xsens Technologies
Amount: RMB 230,000

8. Title: Research on Multi-sensor Fusion Wearable Hand Gesture Recognition for Automatic Sign
   Language Detection
   Role: PI
   Dates: 2020.01.01 – 2021.12.31
   Source: National Natural Science Foundation of China – RFIS-I
   Amount: RMB 321,000

9. Title: Development of a Lower Limb Assistive Soft Exoskeleton
   Role: co-PI
   Dates: 2018.04.30 – 2021.06.30
   Source: Science and Technology Commission of Shanghai Municipality
   Amount: RMB 1,000,000

10. Title: Kids Activity Recognition Algorithm Based on BST Sensors and Transfer Learning
    Role: PI
    Dates: 2020.06.30 – 2020.12.20
    Source: Bosch Sensortec
    Amount: RMB 480,000

11. Title: Hand Gesture Recognition via Wrist-worn Muscle Force Sensing
    Role: PI
    Dates: 2019.09.01 – 2020.04.30
    Source: Huawei Research
    Amount: RMB 600,000

12. Title: Kinematics Analysis and Force Position Control Synthesis of Continuum Robots for Deep
    Cavity Operation
    Role: co-PI
    Dates: 2015.01.01 – 2019.12.31
    Source: National Natural Science Foundation of China – Key Project
    Amount: RMB 3,800,000

13. Title: Human Running Posture and Load Estimation via Wearable Sensors
    Role: PI
    Dates: 2019.05.01 – 2019.10.31
    Source: Huawei Research
    Amount: RMB 500,000

14. Title: Research on a Wearable Sensing and Haptic Feedback Gait Retraining System to Improve
    Knee Osteoarthritis
    Role: PI
    Dates: 2016.01.01 – 2018.12.31
    Source: National Natural Science Foundation of China – Youth Science Foundation
    Amount: RMB 250,000

15. Title: Research on Human Energy Harvesting through Gait Retraining and Regenerative, Smart Shoe Design
    Role: PI
    Dates: 2017.01.01 – 2018.12.31
    Source: National Natural Science Foundation of China – RFIS-I
    Amount: RMB 400,000

16. Title: Machine Learning to Classify Rider Ability and Riding Conditions on Dockless Shared Bikes
    Role: PI
    Dates: 2018.07.01 – 2018.12.31
    Source: Bosch Sensortec
    Amount: RMB 400,000

17. Title: Wearable Sensing and Haptic Feedback for Knee Osteoarthritis
    Role: PI
    Dates: 2016.01.01 – 2018.12.31
    Source: Shanghai Jiao Tong University – Foreign Professor Research Initiative
    Amount: RMB 600,000

18. Title: Soft Robotics Movement Sensing and Feedback for Preventing Falls in Older Adults
    Role: PI
    Dates: 2014.09.01 – 2017.08.31
    Source: University of Michigan – Shanghai Jiao Tong University Collaboration Research Fund
    Amount: RMB 600,000

19. Title: A Wearable Sensing and Haptic Feedback System for Movement Training and Assessment
    Role: PI
    Dates: 2014.07.01 – 2017.06.30
    Source: Science and Technology Commission of Shanghai Municipality (Yangfan Program)
    Amount: RMB 100,000

20. Title: Smart Shoe Development for Interactive Exercising Games
    Role: PI
    Dates: 2015.06.01 – 2016.12.01
    Source: Danyang Chenhui Mechatronics Company
    Amount: RMB 40,000

21. Title: Wearable Sensing and Haptic Feedback System for Human Movement Training and Assessment
    Role: PI
    Dates: 2014.01.01 – 2016.06.30
    Source: China 985 Program at SJTU
    Amount: RMB 500,000

22. Title: Bio-Signal Based Hand and Finger Action Perception (Hand-Gesture Recognizing Wristband)
    Role: PI
    Dates: 2015.05.01 – 2016.06.01

Advising

Postdoctoral Students

Jianping Lin   Postdoctoral Research Fellow, 2023-
Topic: *Smart lower-limb exoskeletons*

Tao Sun   Postdoctoral Research Fellow, 2021-2023
Topic: *AI for wearable biomechanics*

Bingfei Fan   Postdoctoral Research Fellow, 2019-2022
Topic: *Wearable system modeling for sports applications*

Jean-Baptiste Chossat   Postdoctoral Research Fellow, 2018-2020
Topic: *Soft acoustic waveguides and twisted/coiled polymer actuators*

Daniel Chen   Postdoctoral Research Fellow, 2018-2020
Topic: *Wearable systems for improving human computer interaction*

Doctoral Students

Kezhe Zhu   Ph.D. Candidate, 2024-
Topic: *Wearable IMU modeling*

Hong Wang   Ph.D. Candidate, 2023-
Topic: *Wearable system algorithms and design*

Yueyuan Chen   Ph.D. Candidate, 2023-
Topic: *Wearable intelligent systems*

Zakir Ullah   Ph.D. Candidate, 2022-
Topic: *Haptics and artificial intelligence to improve rehabilitation*

Peiqi Kang   Ph.D. Candidate, 2022-
Topic: *Movement classification for human computer interaction*

Jinxuan Li   Ph.D. Candidate, 2021-
Topic: *IMU-based human movement modeling*

Yuan Lin   Ph.D. Candidate, 2019-
Topic: *Soft acoustic waveguides*

David Chiasson   Ph.D. 2023
Thesis Title: *Key technologies in indoor human localization via inertial sensing ultra wide-band*

Xinyu Song	Ph.D. 2022 Thesis Title: *Research on wearable serious game-based training approach for upper limb motor function rehabilitation after stroke*
Tian Tan	Ph.D. 2021 Thesis Title: *Knee load modeling and estimation via wearable and portable sensing*
Shuo Jiang	Ph.D. 2020 Thesis Title: *Research on wearable human-machine interface for hand gesture recognition via multi-modality sensing*
Haisheng Xia	Ph.D. 2020 Thesis Title: *Foot progression angle assessment and modification for knee osteoarthritis via novel smart shoe design*
Yangjian Huang	Ph.D. 2019 Thesis Title: *Gait assessment and training to reduce loading during walking and running*

Masters Students

Ziheng Xu	M.S. Candidate, 2023- Topic: *Wearable IMU algorithm development*
Chenquan Xu	M.S. Candidate, 2023- Topic: *Real-time IMU Kinetics Modeling*
Omar Mansour	M.S. Candidate, 2023- Topic: *Wearable system design*
Hussein Sarwat	M.S. Candidate, 2022- Topic: *Artificial Intelligence for portable rehabilitation*
Huiming Pan	M.S. Candidate, 2022- Topic: *Sparse sensor networks for human movement*
Yidong He	M.S. Candidate, 2022- Topic: *Computer vision and IMU sensor fusion*
Dongxuan Li	M.S. Candidate, 2021- Topic: *Wearable hand gesture recognition*
Medhanit Yekunoamlak	M.S. Candidate, 2021- Topic: *Soft sensing and feedback*
Peiqi Kang	M.S. 2022 Thesis Title: *Development of gesture recognition system and robust algorithm*

based on wearable motion sensor

Dianxin Wang   M.S. 2021
Thesis Title: *Development of wearable system and research in estimation of knee moment during walking*

Qinghua Gao   M.S. 2021
Thesis Title: *Research on gesture recognition based on multimodal fusion perception and its wearable device application*

Jonathan Maglott   M.S. 2021
Thesis Title: *Exploring the influence of physiology and perception on basketball free throw shooting performance via wearable systems*

Zachary Strout   M.S. 2020
Thesis Title: *Simultaneous estimation of running gait parameters with a multi-output convolution neural network*

Daiyan Peng   M.S. 2020
Thesis Title: *A smart sensing system for road condition classification via lock embedded IMU on dock-less shared bikes*

Fangyuan Cao   M.S. 2019
Thesis Title: *Development and research of a wearable rehabilitation motion training system based on tactile feedback*

Bo Yu   M.S. 2016
Thesis Title: *Research and development of a wearable sensing system used to monitor human trunk sway*

Teaching

Design and Manufacturing II (ME209 4 Units, Undergraduate Course, <u>New Course Co-Developed by Shull</u>, Instructor). This course covers the basics of mechanism and machine design. Specific topics include kinematics, dynamics, mechanism synthesis, design and selection of machine components, and actuators. This is a project-based course where students work in teams to a complete project. *Shanghai Jiao Tong University (40 students): Fall 2015, Fall 2016, Fall 2017, Fall 2018, Fall 2019, Fall 2020, Fall 2021, Fall 2022, Fall 2023, Fall 2024.*

Wearable Systems (ME26012, 3 Units, Graduate Course, <u>New Course Developed by Shull</u>, Instructor). This graduate course serves as an introduction to the emerging field of wearable systems. Lecture content covers various engineering aspects of wearable systems including wearable haptics design and application, sensor type and selection, and inertial algorithm development and highlights clinical and sports applications. Students perform hands on laboratory testing with commercial and research wearable devices. Data is compiled and analyzed by small teams of students who present findings in a comprehensive written report and an oral presentation at the end of the semester. *Shanghai Jiao Tong University (30 students): Fall 2014, Fall 2016, Fall 2018, Fall 2020, Fall 2022.*

Dynamics (E15, 3 Units, Undergraduate Course, Teaching Assistant). The application of Newton's Laws to solve static and dynamic problems, particle and rigid body dynamics, freebody diagrams, and writing equations of motion. 2-D and 3-D cases including gyroscopes, spacecraft, and rotating machinery. Solution of equations of motion and dynamic response of simple mechanical systems. Led weekly homework sessions for about fifteen students, gave two lectures, and helped grade exams. *Stanford University (80 students): Fall 2006, Fall 2007.*

Introduction to Robotics (CS 223A, 3 Units, Graduate Course, Teaching Assistant). Robotics foundations in modeling, design, planning, and control. Class covers relevant results from geometry, kinematics, statics, dynamics, motion planning, and control, providing the basic methodologies and tools in robotics research and applications. Concepts and models are illustrated through physical robot platforms, interactive robot simulations, and video segments relevant to historical research developments or to emerging application areas in the field. Held weekly office hours, maintained the course website, and designed and graded the midterm and final exams. *Stanford University (50 students): Winter 2008.*

Advanced Robotics (CS 223A, 3 Units, Graduate Course, Teaching Assistant). Emerging areas of human-centered robotics and interactive haptic simulation of virtual environments. Topics: redundancy; task-oriented dynamics and control, whole-body control-task and posture decomposition, cooperative robots, haptics and simulation, haptically augmented teleoperation, human-friendly robot design. Held weekly office hours, maintained the course website, and designed and graded the final exam. *Stanford University (15 students): Spring 2008.*

Service

1. Associate Editor: Nature npj Digital Medicine, 2022-

2. Associate Editor: IEEE Journal of Biomedical and Health Informatics, 2021-

3. Associate Editor: IEEE Transactions on Neural Systems and Rehabilitation Engineering, 2017-

4. Associate Editor: Wearable Technologies, 2019-

5. Associate Editor: Special Issue, Frontiers in Physiology: Wearable Sensing of Movement Quality after Neurological Disorders, 2022

6. Technical Committee Member: IEEE Engineering in Medicine and Biology (EMB) Technical Committee on Wearable Biomedical Sensors and Systems, 2017-

7. Technical Committee Member: IEEE International Conference on Wearable and Implantable Body Sensor Networks (BSN), 2019

8. Technical Committee Member and Session Chair: International Conference on Robotics and Automation Sciences, Wuhan, China, June 2018

9. Editorial Board Member: IEEE Open Journal of Engineering in Medicine and Biology, 2019-

10. Conference Session Chair: International Society of Biomechanics, Brisbane, Australia, July 2017 Session Title: Injury and Rehabilitation.

11. Conference Session Chair (Irene Davis, co-chair): World Congress of Biomechanics, Boston, MA, USA, July 2014
    Session Title: Gait Modification Symposium

12. Undergraduate Freshmen Advisor: Shanghai Jiao Tong University, 2016-2017
    Advised a group of 25 freshmen mechanical engineering students

13. Mechanical Engineering International Student Union Advising Instructor: Shanghai Jiao Tong University, 2018-2019

14. Committee member to improve and reform undergraduate education in mechanical engineering at Shanghai Jiao Tong University
    Resulting presentation at Reimagine Education Awards Conference, Philadelphia, PA, USA, December 2016

15. Reviewer: *Nature, IEEE Journal of Biomedical Health Informatics, IEEE Sensors, IEEE Transactions on Cybernetics, IEEE Transactions on Haptics, IEEE Transactions on Mechatronics, IEEE Transactions on Neural Systems and Rehabilitation Engineering, IEEE Transactions on Robotics, Journal of Biomechanics, Gait and Posture, Clinical Biomechanics, Journal of Orthopaedic Research, Journal of Neuroengineering and Rehabilitation, Sensors, Journal of Applied Biomechanics, Medicine and Science in Sports and Exercise, Plos One, Human Movement Science, Medical Engineering and Physics, BMJ Open, Journal of Sports Sciences, Journal of Medical and Biological Engineering, Medical and Biological Engineering and Computation, Archives of Physical Medicine and Rehabilitation, Journal of Engineering in Medicine, International Conference on Robotics and Automation (ICRA), World Haptics Conference, Haptics Symposium Conference, Eurohaptics Conference, International Conference on Robotics Rehabilitation (ICORR)*

Other

Consulting: *AlterG, CalaHealth, MotionIQ, RAND-Europe, Vibrado Technologies*