Sanghyun Kim

Current Affiliation

Ph.D. Candidate (expected in 2020.2) at the Department of Transdisciplinary Studies,
Graduate School of Convergence Science and Technology,
Seoul National University

Visiting Researcher (until 2019.6) at the Gepetto Team,
Laboratory for Analysis and Architecture of Systems (LAAS),
Centre National de la Recherche Scientifique (CNRS)

Contact Information

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Education

Seoul National University, Seoul, Korea **2012.3 - Presence**
Ph.D. Candidate of Dept of Trandisciplinary Studies
- Lab: Dynamic Robotic System Lab (DYROS Lab, https://dyros.snu.ac.kr)
- Advisor: Professor Jaeheung Park (park73@snu.ac.kr)

Seoul National University, Seoul, Korea **2005.3 - 2012.2**
B.A., Mechanical Engineering, March, 2012

Visiting Experience

Centre National de la Recherche Scientifique (CNRS), France **2018.8 - Presence**
Visiting Researcher
- Lab: Gepetto Team (http://projects.laas.fr/gepetto)
- Advisor: Dr. Nicolas Mansard (nmansard@laas.fr)
- Funding: Korean government grant

Gwangju Institute of Science and Technology (GIST), Korea **2010.6 - 2010.9**
Student Internship
- Lab: Haptic Team (http://dyconlab.gist.ac.kr)
- Advisor: Professor Jeha Ryu (ryu@gist.ac.kr)

Research Interests

Hierarchical whole-body control of bipedal robot and mobile-based humanoid
Task and contact transition algorithm for hierarchical controller
Torque-based task space control
Whole-body planning for high redundant robot
Dexterous robot hand control
Manipulation of redundant robotic system

Research Experience

During visiting researcher in Gepetto Team, LAAS-CNRS, France

Whole-body Planning for Humanoid **2018 - Presence**
- (Ongoing Work) Generating contact sequence, CoM trajectory, feet trajectories, and whole-body trajectory for legged robots.
  - ✓ Video: https://youtu.be/JpwigzMQg6E
- Implementation of CoM trajectory generator based on *Time Optimization*.
- Implementation of feet trajectories using the concept of hyper-plane.
- Implementation of Quadratic Programming (QP)-based whole-body planner in C++ and Python:
  - ✓ Video: https://youtu.be/nHiLV89cMG8
  - ✓ Codes: https://github.com/ggory15/tsid_python_binding

Model Predictive Control for Humanoid **2018 - Presence**

- (Ongoing Work) Developing whole-body controller using Differential Dynamic Programming (DDP).
- (Ongoing Work) Implementation of DDP-based controller with the collision avoidance constraint.
  - ✓ (Preliminary) Video : https://youtu.be/rq3dXdt8t0E

During Ph.D. student

Whole-body Control of Torque-controlled Humanoids **2014 - Presence**

- Design and development of torque-controlled humanoid, DYROS-Red [C3].
  - ✓ EtherCAT and RTX programming for real-time control
  - ✓ High-level controller: Whole-body controller
  - ✓ Low-level controller: Elmo motion controller
  - ✓ Video : https://youtu.be/01E-rKixNfE
- Implementation of whole-body controllers for torque-controlled humanoids.
  - ✓ Using operational-space controller [C3]
  - ✓ Using hierarchical QP-based controller [J3]
  - ✓ Using DDP-based controller
- (Ongoing Work) Development contact force generator with multi-constraints for dynamic balance.

Multiple Task Execution Algorithm **2017 - Presence**

- Dynamic task transition algorithm to generate complex behavior.
- Continuous transitions between arbitrary tasks using the activation parameter [J3].
  - ✓ Insertion and removal both equality and inequality tasks without discontinuity of the control input.
  - ✓ Development of avoidance tasks including joint-limit, singularity, and obstacle.
  - ✓ Video : https://youtu.be/-lfnLhmSk3M
  - ✓ Codes: https://ggory15.github.io/tasktransition-project
- (Ongoing Work) Applying the task transition method to operate mobile-based humanoid
  - ✓ Development controller for archiving complex tasks [O2]
  - ✓ Self-collision avoidance algorithm using the concept of attractive force [O1]
  - ✓ Video : https://youtu.be/K8RnMAA0rg4
  - ✓ Video : https://youtu.be/FyiSZ1lomSs
- (Ongoing Work) Multi-contact transition for humanoids using Gravito-Inertial Wrench Cone (GIWC)

Control of Position-controlled Humanoids **2014 - 2018**

- Design and development of position-controlled humanoid, DYROS-Jet [J1].
  - ✓ RS-232 communication with 200 Hz
  - ✓ High-level controller: Jacobian-based controller
  - ✓ Low-level controller: Robotis controller
  - ✓ Video : https://youtu.be/9UwJQREUjtc
- Implementation of inverse kinematics controllers for position-controlled humanoids
  - ✓ using Jacobian-based inverse kinematics controller [J1, C4, W2]
  - ✓ using Forward And Backward Reaching Inverse Kinematics (FABRIK) [C8]
  - ✓ using Recursive Neural Network (RNN) [C7]
- Disturbance observer to enhance balancing performance [C6]
  - ✓ Feed-forward joint disturbance observer for compliant motion
  - ✓ Video: https://youtu.be/LHGxx0M9ijs

Singularity avoidance algorithm **2016 - 2017**

- Comparative analysis of six representative singularity avoidance algorithms:
  Damped Pseudo Inverse, Error Damped Pseudo Inverse, Jacobian Transpose, Selectively Damped Inverse, Filtered Inverse, and Task Transition Method

Development of humanoid system for DRC Finals 2015 **2014 - 2016**

- Student leader of Team SNU
  - ✓ Managing the whole framework of robot
  - ✓ Developing the upper-body and lower-body position controller
- No falling down during the competitions and 12th in DRC Finals 2015 [J1, C4, B1, W2]
  - ✓ Video: https://youtu.be/aWpyfKkbzf0

Artificial intelligence robot CPR system **2014 - 2016**

- Robot manipulator to perform CPR in emergency situations [P1, P3, C5]
- Automatic System based biological data from a patient
- Simulation on mannequin and animal test
  - ✓ Video: https://youtu.be/D9saZERvzf8

Robot hand tele-operation control **2012 - 2014**

- Robot hand synergy mapping using multi-factor model [P2, C2, W1]
- Extracting synergy by considering individual characteristic as well as grasping motion
  - ✓ Video: https://youtu.be/QzGgV9KHaZI
- Grasping Force Estimation using sEMG signals [J2]

Tele-opeartion control of ultrasonic examination system **2012 - 2013**

- Tele-operated robotic arm for remote ultra-sound exam
- Automated orientation control for ultrasound
- Contact force feedback using haptic device
  - ✓ Video: https://youtu.be/_OSkL5e70fI

During internship in GIST, Korea

Friction and Gravity Compensator for Surgery Simulator **2010.6 - 2010.9**

- Research and development on the Laparoscopic simulator
- Haptic Feedback using friction and gravity compensator [C1]

Technical skills

Hardware Experience

Human-sized Humanoids

- Torque controlled robot, *DYROS-Red*
- Position controlled robot, *DYROS-Jet*
- Torque controlled robot, *TALOS (PAL Robotics Co.)*
- Position controlled robot, *HRP-2*

Mobile-based Humanoids

- Four-wheeled mobile base, *Husky*, with 7-DoF arm, *Franka Panda*

Manipulator

- 7-DoF arm, *Franka Panda*
- 6-DoF arm, *Roman-3D*
- 6-DoF arm, *Denso Arm*

Software Experience

Programming Skills

- Intermediate C++, Python, and Matlab programming for robotics (Windows, Ubuntu 16.04)
- V-Rep, MuJoCo, Gazebo, and Pinocchio for robotic simulation

Libraries

- Math - Eigen, Lapack, MKL
- Optimization - qpOASES, Eiquadprog, IFOPT and IPOPT
- Robot Kinematics and Dynamics: Pinocchio, RBDL
- Others: Boost (in particular, boost-python), FCL

Honors and Awards

Korean government grant for Visiting Scholar of LAAS-CNRS, 2018.
Best paper award in Journal of Korea Robotics Society (JKROS), 2018.
Cum laude from Dept. of Mechanical Engineering at Seoul National University, 2012.

Patents

[P3] **Sanghyun Kim** *et al.* Automatic cardiopulmonary resuscitation device and control method therefor, US Patent, No. 20190029919A1, CN Patent, No. 108697572A, EU Patent, No. 3409258A1, 2019

[P2] **Sanghyun Kim**, Jaeheung Park, Mingon Kim, Jimin Lee, Jounghuem Kwon, Bumjae You. APPARATUS FOR ESTIMATING GRASPING POSTURE AND GRASPING FORCE. Korea Patent, No.10-2016-0075150, 2016.

[P1] **Sanghyun Kim** *et al.* APPARATUS FOR AUTOMATIC CARDIOVASCULAR PULMONARY RESCITATION. Korea Patent, No.10-2016-0011876, 2016.

International Journal Articles

[J3] **S. Kim**, K. Jang, S. Park, Y. Lee, S. Y. Lee, and J. Park, Continuous Task Transition Approach for Robot Controller based on Hierarchical Quadratic Programming, IEEE Robotics and Automation Letters (with ICRA 2019 presentation), Vol. 4, No. 2, pp. 1603-1610, 2019

[J2] **S. Kim**, M. Kim, J. Kim, S, Kim, and J. Park. Grasping Force Prediction by EMG Signals and Arm Posture: Tensor Decomposition Based Approach, International Journal of Bionic Engineering, conditionally accepted, 2019

[J1] **S. Kim**, M. Kim, J. Lee, S. Hwang, J. Chae, B. Park, H. Cho, J. Sim, J. Jung, H. Lee, S. Shin, M. Kim, W. Choi, Y. Lee, S. Park, J. Oh, Y. Lee, S. Lee, M. Lee, S. Yi, K. Chang, N. Kwak, and J. Park. Team SNUs Control Strategies to Enhancing Robots Capability: Lessons from the DARPA Robotics Challenge Finals 2015. Journal of Field Robotics, Vol. 34, No. 2, pp. 359-380, 2017

International Conference Articles

[C8] **S. Kim**, J. Kim, and J. Park. Real-time Inverse Kinematics Technique for Controlling Humanoid Avatar with Redundant Arm, Ubiquitous Robot 2018, Hawaii, USA, 2018.

[C7] M. Kim, J. Kim, **S. Kim**, J. Sim, and J. Park. Disturbance Observer based Linear Feedback Controller for Compliant Motion of Humanoid Robot, International Conference on Robotics and Automation, Australia, 2018.

[C6] M. Kim, **S. Kim**, and J. Park. Human Motion Imitation for Humanoid by Recurrent Neural Network. The 13th International Conference on Ubiquitous Robots and Ambient Intelligence, Xian, China, 19-22 Aug, 2017.

[C5] J. Jung, J. Kim, **S. Kim**, W. Kwon, S. Na, K. Kim, J. Lee, G. Suh, and J. Park. Application of Robot Manipulator for Cardiopulmonary Resuscitation, International Symposium on Experimental Robotics, Tokyo, Japan, 2016.

[C4] **S. Kim**, M. Kim, J. Lee, S. Hwang, J. Chae, B. Park, H. Cho, J. Sim, J. Jung, H. Lee, S. Shin, M. Kim, N. Kwak, Y. Lee, S. Lee, M. Lee, S. Yi, K. K.C. Chang, and J. Park. Approach of Team SNU to the DARPA Robotics Challenge Finals. 2015 IEEE-RAS International Conference on Humanoid Robots, Seoul, Korea, 3-5 Nov 2015.

[C3] M. Schwartz, S. Hwang, Y. Lee, J. Won, **S. Kim**, and J. Park. Aesthetic Design and Development of Humanoid Legged Robot. The 2014 IEEE-RAS International Conference on Humanoid Robots, Madrid, Spain, 18-20 Nov 2014.

[C2] **S. Kim**, M. Kim, J. Lee, and J. Park. Robot Hand Synergy Mapping Using Multi-factor

Model and EMG signal. International Symposium on Experimental Robotics, Marrakech/Essaouira, Morroco, 15-18 June 2014.

[C1] **S. Kim**, C. Lee, and J. Ryu. Data-driven Haptic Rendering of Friction between Surgical Device and Trocar for Laparoscopic Surgery Simulator, The 6th Asian Conference on Computer Aided Surgery (ACCAS), Busan, Korea, 2010.

Book Chapter

[B1] **S. Kim**, M. Kim, J. Lee, S. Hwang, J. Chae, B. Park, H. Cho, J. Sim, J. Jung, H. Lee, S. Shin, M. Kim, W. Choi, Y. Lee, S. Park, J. Oh, Y. Lee, S. Lee, M. Lee, S. Yi, K. Chang, N. Kwak, and J. Park. Team SNUs Control Strategies to Enhancing Robots Capability: Lessons from the DARPA Robotics Challenge Finals 2015, The DARPA Robotics Challenge Finals: Humanoid Robots to the Rescue, Springer, pp. 347-379, 2018.

Workshops

[W2] **S. Kim** and J. Park. Control Strategies of Team SNU for DRC Finals, and Future Directions for Robots in Human Environment. Invited speaker at Workshop on What did we do for the DARPA Robotics Challenge?, 2015 IEEE-RAS International Conference on Humanoid Robots, Seoul, Korea, 3-5 Nov 2015.

[W1] **S. Kim**, J. Lee, M. Kim, and J. Park. Teleoperated Robot Hand Control using Tensor Decomposition. Full-day Tutorial on Robotics-based Methods for the Identification, Recognition, and Synthesis of Human Motions, IEEE/RSJ International Conference on Intelligent Robots and Systems, Tokyo, Japan, 3 Nov 2013.

Ongoing Papers

[O2] **S. Kim**, K. Jang, S. Park, Y. Lee, S. Y. Lee, and J. Park, Whole-body Control of Non-holonomic Mobile Manipulator Based on Hierarchical Quadratic Programming and Continuous Task Transition. IEEE International Conference on Advanced Robotics and Mechatronics (ARM), under review, 2019.

[O1] K. Jang, **S. Kim**, S. Park, S. Kim, and J. Park, Real-Time Self-Collision Avoidance based on Attractive Force and Torque for Differentially Driven Mobile Manipulators, IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), under review, 2019.