

# Sungkyu Jung

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Date: December 15, 2018

## Education

Ph.D. in Statistics, University of North Carolina at Chapel Hill.	2006–2011
B.S. in Statistics, Seoul National University.	1999–2003

## Academic Appointments

Department of Statistics, Seoul National University	
Associate Professor	2018—
Department of Statistics, University of Pittsburgh	
Associate Professor	2017—
Director of Graduate Studies	2017—2018
Assistant Professor	2011–2017

## Honors, Awards & Fellowships

Early Career Development Award, Korean International Statistical Society, 2016.  
US Junior Oberwolfach Fellow, NSF DMS-1049268 (MFO, Germany), 2014.  
Distinguished Paper Awards, International Biometric Society/ENAR, 2011.  
GSPF Travel awards, University of North Carolina, 2010.  
Graduate Fellow, SAMSI, 2010–2011.  
Wassily Hoeffding Award, Statistics and Operations Research, University of North Carolina, 2007.

## Research Interests

- Modern Multivariate Statistics
- Non-Euclidean data analysis
- High-dimension, low-sample-size (HDLSS) analysis
- Shape analysis
- Data fusion
- Geometrically-constrained inference

## Research Grants

PI, internal grant, Seoul National University, “Bias adjustments in high-dimensional principal component analysis,” KRW40,000K, 2018-2019.

PI, dB-SERC, University of Pittsburgh, “Creasing an undergraduate course for Principles of Data Science”, \$10,000. 2017-2018.

PI, Central Research Development Fund, University of Pittsburgh, “Statistical Analysis of Geometrically Constrained Data”, \$12,000, 2016-2018. (Sole PI)

PI, NSF grant DMS-1307178 “Statistical Analysis of High Dimensional Manifold Data” \$110,000, 2013–2016. (Sole PI)

PI, Hewlett International Grant, UCIS, University of Pittsburgh “International conference (IMS-APRM) travel funding”, \$1,500, 2016.

PI, Hewlett International Grant, UCIS, University of Pittsburgh “International conference (World Statistics Congress) travel funding”, \$1,500, 2013

PI, Hewlett International Grant, UCIS, University of Pittsburgh “International conference (IMS-APRM) travel funding”, \$1,500, 2012.

Co-I, NIH (NCI) project 5R01CA159471-03 “Free-Breathing Perfusion MRI of the Abdomen with Predictive Motion Correction” PI: Michael Gach, \$235,523 (5%), 2011–2014.

## Research Publications

### *Papers Submitted / Under Revision*

\* Ph.D. students are underlined>.

1. **Sungkyu Jung**, Jeongyeon Ahn and Yongho Jeon, “Penalized Orthogonal Iterations for Sparse Estimation of Generalized Eigenvalue Problems”, submitted to *Journal of Computational and Graphical Statistics*.
2. Byungwon Kim, Jörn Schulz, Stephan Huckemann and **Sungkyu Jung**. “Small sphere distributions for directional data with application to medical imaging”, revision invited, *Scandinavian Journal of Statistics*. arXiv:1705.10013 [stat.ME]
3. Zhao Ren, **Sungkyu Jung** and Xingye Qiao. “Covariance-engaged classification of sets via linear programming”, submitted to *Journal of Machine Learning Research*.
4. David Groisser, **Sungkyu Jung**, and Armin Schwartzman. “Uniqueness questions in a scaling-rotation geometry on the space of symmetric positive-definite matrices”, submitted to *Differential Geometry and its Applications*.
5. **Sungkyu Jung**. “Adjusting systematic bias in high dimensional principal component scores”, submitted, *Bernoulli*.
6. Sungwon Lee and **Sungkyu Jung**. “Combined Analysis of Amplitude and Phase Variations in Functional data”, arXiv:1603.01775 [stat.ME]

## Publications

7. Sandra E Safo, Jeongyoun Ahn, Yongho Jeon, and **Sungkyu Jung**. "Sparse generalized eigenvalue problem for canonical correlation analysis with application to integrative analysis of methylation and gene expression data", to appear in *Biometrics*.
8. **Sungkyu Jung**, Myunghee Lee and Jeongyoun Ahn (2018). "On the number of principal components in high dimensions", *Biometrika* 105(2), 389-402.
9. **Sungkyu Jung** (2018). "Continuum Directions for Supervised Dimension Reduction", *Computational Statistics & Data Analysis* 125, 27-43.
10. Gen Li and **Sungkyu Jung** (2017). "Incorporating Covariates into Integrated Factor Analysis for Multi-View Data", *Biometrics* 73 (4), 1433-1442.
11. David Groisser, **Sungkyu Jung**, and Armin Schwartzman (2017). "Geometric foundations for statistics on symmetric positive definite matrices: characterizations of minimal scaling-rotation curves in low dimensions", *Electronic Journal of Statistics*, Vol. 11, No. 1, 1092-1159.
12. Hao Song, Dan Ruan, Wenyang Liu, V. Andrew Stenger, Rolf Pohmann, Maria A. Fernandez Seara, Tejas Nair, **Sungkyu Jung**, Jingqin Luo, Yuichi Motai, Jingfei Ma, John D. Hazle and H. Michael Gach (2017). "Respiratory motion prediction and prospective correction for free-breathing arterial spin labeled perfusion MRI of the kidneys", *Medical Physics* 44, 962-973.
13. **Sungkyu Jung**, Armin Schwartzman and David Groisser (2015). "Scaling-rotation distance and interpolation of symmetric positive-definite matrices", *SIAM Journal on Matrix Analysis and Applications*, 36(3), 1180-1201.
14. Jörn Schulz, **Sungkyu Jung**, Stephan Huckemann, Michael Pierrynowski, J. S. Marron, Stephen M. Pizer (2015). "Analysis of rotational motion from directional data", *Journal of Computational and Graphical Statistics*, 24(2), 539-560.
15. Benjamin Eltzner, **Sungkyu Jung** and Stephan Huckemann (2015). "Dimension Reduction on Poly-spheres with Application to Skeletal Representations" *Geometric Science of Information*. Springer International Publishing, 2015. 22-29. (Peer-reviewed full paper)
16. Hao Song, Wenyang Liu, Dan Ruan, Rolf Pohmann, V. Andrew Stenger, Maria A. Fernandez Seara, **Sungkyu Jung**, H. Michael Gach (2015). "Free-Breathing Perfusion MRI Using Multislice PCASL", in *2015 IEEE International Symposium on Biomedical Imaging (ISBI)*, pp. 1474-1477. (Peer-reviewed full paper)
17. **Sungkyu Jung** (2014). "Dimension reduction for directions and 2D shapes" in *Oberwolfach Reports*, Volume 11, Issue 4, 2481-2527.
18. Stephen M. Pizer, Junpyo Hong, **Sungkyu Jung**, J.S. Marron, Joern Schulz, and Jared Vicory (2014). "Relative Statistical Performance of S-reps with Principal Nested Spheres vs. PDMs," *Proc. Shape 2014 - Symposium of Statistical Shape Models and Applications*. Delémont, Switzerland, June 11-13 2014:10.
19. **Sungkyu Jung** and Xingye Qiao (2014). "A statistical approach to set classification by feature selection with applications to classification of histopathology images", *Biometrics*, 70, 536-545.
20. **Sungkyu Jung** and Jason Fine (2013). Comment on "Large Covariance Estimation by Thresholding Principal Orthogonal Complements" by Fan, Liao and Mincheva, *Journal of Royal Statistical Society, Series B*, 75(4), 666-666.
21. Gach H. M., Price J. C., Davis D. K., **Jung S.**, Carney J. P., Ruszkiewicz J. A., Lopresti B. J., Laymon C. M., Mathis C. A. (2013) "Analysis of Tissue Properties and MRI Signals in the Head for PET/MRI Attenuation Correction". *Proceedings of the 21st Annual Meeting of the ISMRM*, Salt Lake City, UT, April 20-26, 2013: 4358. (Peer-reviewed full paper)

22. Stephen M. Pizer, **Sungkyu Jung**, Dibyendusekhar Goswami, Xiaojie Zhao, Ritwik Chaudhuri, James N. Damon, Stephan Huckemann, J. S. Marron (2013). "Nested Sphere Statistics of Skeletal Models," in *Innovations for Shape Analysis: Models and Algorithms*, M. Breuß, Bruckstein and Maragos (Eds), Springer, Berlin, 93-115. (Peer-reviewed full paper)
23. **Sungkyu Jung**, Arusharka Sen and J. S. Marron. (2012). "Boundary behavior in high dimension, low sample size asymptotics of PCA," *Journal of Multivariate Analysis*, 109, 190–203.
24. **Sungkyu Jung**, Ian L. Dryden and J. S. Marron. (2012). "Analysis of Principal Nested Spheres," *Biometrika*, 99(3), 551-568.
25. **Sungkyu Jung** (2011). "A Backward Generalization of PCA for Exploration and Feature Extraction of Manifold-Valued Shapes," in *Recent Advances in Functional Data Analysis and Related Topics*, F. Ferraty (Ed), 183-188.
26. **Sungkyu Jung**, Mark Foskey and J. S. Marron (2011). "Principal Arc Analysis on direct product manifolds," *The Annals of Applied Statistics*, 5, 578-603.
27. **Sungkyu Jung**, Xiaoxiao Liu, J. S. Marron and Stephen M. Pizer (2010). "Generalized PCA via the backward stepwise approach in image analysis," in *Brain, Body and Machine: Proceedings of an International Symposium on the 25th Anniversary of McGill University Centre for Intelligent Machines*, J. Angeles et al. (Eds.) *Advances in Intelligent and Soft Computing* 83, 111–123. (Peer-reviewed full paper)
28. J. S. Marron, **Sungkyu Jung**, Ian L. Dryden (2010). "Speculation on the Generality of the Backward Stepwise View of PCA," *Proceedings of MIR 2010: 11th ACM SIGMM International Conference on Multimedia Information Retrieval*, Association for Computing Machinery, Inc., Danvers, MA, 227-230. (Peer-reviewed full paper)
29. **Sungkyu Jung**, Mark Foskey and J. S. Marron (2010). Discussion on "Intrinsic shape analysis: Geodesic PCA for Riemannian manifolds modulo isometric lie group actions" by Huckemann, Hotz and Munk, *Statistica Sinica* 20, 63-65.
30. **Sungkyu Jung** and J. S. Marron (2009). "PCA consistency in high dimension, low sample size context," *The Annals of Statistics* 37, 4104-4130.

#### *Papers to be submitted/ in preparation*

1. **Sungkyu Jung**. "Inference on subspheres model for directional data", arXiv preprint. arXiv:1606.03998 [math.ST].
2. Brian Rooks, David Groisser, Armin Schwartzman and **Sungkyu Jung**. "Statistical analysis of random symmetric positive-definite matrices via eigen-decomposition", in preparation.
3. **Sungkyu Jung**, Sungwon Lee, Xing Gao and Gen Li. "SCARF: Structured, Covariate-Adjusted, and Regularized Factorization", in preparation.
4. David Groisser, **Sungkyu Jung** and Armin Schwartzman. "A scaling-rotation metric on the space of symmetric positive-definite matrices", in preparation.
5. **Sungkyu Jung**, Stephan Huckemann, J. S. Marron, Huiling Le and Thomas Hotz. "Reduction of Object Features", in preparation.

## Talks and Presentations

Invited talks are marked by \*.

Incorporating Covariates into Integrated Factor Analysis for Multi-View Data

1. SNU International Statistics Workshop, Seoul National University, Seoul, Jan. 2018.\*
2. ICSA Applied Statistics Symposium, Chicago, June 2017.\*

On random symmetric positive-definite matrices

3. Mathematisches Forschungsinstitut Oberwolfach, Jan. 2018.\*
4. Florida State University, Oct. 2017.\*
5. Joint Statistical Meetings, Chicago, July 2016.\*
6. Florida State University, April 2016.\*

On the number of principal components in high dimensions

7. Dagstat 2019, Munich, Germany, Mar. 2019.
8. CMStatistics, Pisa, Italy, Dec. 2018.\*
9. Seoul National University, Seoul, Korea, May 2017.\*
10. International Conference on Current Issues in Modern Statistical Theory and Their Applications, Research Center for Data Science, Seoul, Korea, July 2016.\*
11. Yonsei University, Korea, June 2016.\*
12. IMS Asis Pacific Rim Meeting, Hong Kong, June 2016.\*

Continuum Discriminant Directions And Their Asymptotic Properties

13. University of Texas, Austin. Apr. 2015.\*
14. IMS Asis Pacific Rim Meeting, Taipei, Taiwan, July 2014.\*
15. ISBIS and SLDM meeting on Data Mining in Business and Industry, June 2014.\*

Reduction Of Object Features With Application To Statistical Shape Analysis

16. Mathematisches Forschungsinstitut Oberwolfach, September 2014.\*
17. Carnegie Mellon University, Nov. 2013.\*
18. Seoul National University, Korea, May 2013.\*
19. Stereology, Spatial Statistics and Stochastic Geometry, 7th International Conference, Prague, Czech Republic, June 2012.\*

General Consistency Of Principal Component Analysis

20. The 59th World Statistics Conference, Hong Kong, China, Aug. 2013.\*
21. European Meeting of Statisticians, Budapest, Hungary, July 2013.
22. Joint Statistical Meetings, San Diego, Aug. 2012.
23. University of Göttingen, June 2012.\*

A Backward Generalization Of PCA For Exploration And Feature Extraction Of Manifold-Valued Shapes

24. Department of Biostatistics, University of Pittsburgh, Mar. 2012.\*
25. BIRS workshop—Geometry for Anatomy, Banff, Canada, Sep. 2011.

26. The 2nd International Workshop on Functional and Operational Statistics, Santander, Spain, June 2011.\*
27. AOOD Transition workshop, SAMSI, June 2011.
28. ENAR 2011 Spring Meeting, Miami, Mar. 2011. (Awarded as a Distinguished Student Paper)

#### Statistical Analysis Of Data On Curved Manifolds

29. Emory University, Aug. 2012.\*
30. University of Georgia, Aug. 2012.\*
31. The 14th Meeting of New Researchers in Statistics and Probability, San Diego, July 2012.
32. Korea University, Korea, July 2012.\*
33. University of Pittsburgh, Feb. 2011.\*
34. Michigan State University, Jan. 2011.\*
35. North Carolina State University, Jan. 2011.\*
36. Pennsylvania State University, Jan. 2011.\*
37. University of Chicago, Nov. 2010.\*
38. University of South Carolina, Feb. 2010.\*

#### PCA Consistency In High Dimension, Low Sample Size Context

39. International Conference on Current Issues in Modern Statistical Theory and Their Applications, Research Center for Data Science, Seoul, Korea, July 2012.\*
40. The second IMS Asia Pacific Rim Meeting, Tsukuba, Japan, July 2012.
41. 2010 Joint Statistical Meeting, Aug. 2, 2010.

#### *Workshops attended (Invitation-only)*

1. Statistics for Data with Geometric Structure, Mathematisches Forschungsinstitut Oberwolfach, Oberwolfach, Germany, Jan. 2018.
2. SNU International Statistics Workshop, Seoul National University, Seoul, Jan. 2018.
3. Workshop on Applications-Driven Geometric Functional Data Analysis, Florida State University, Tallahassee, FL, Oct. 2017.
4. Mini-Workshop on Asymptotic Statistics on Stratified Spaces, Mathematisches Forschungsinstitut Oberwolfach, Oberwolfach, Germany, Sep. 2014.
5. The 14th Meeting of New Researchers in Statistics and Probability, San Diego, CA, July 2012.
6. BIRS workshop on Geometry for Anatomy, Banff, Canada, Sep. 2011.

#### *Presentations by Supervised Students*

Ph.D. Students are underlined.

1. Brian Rooks and **Sungkyu Jung**, "Averaging symmetric positive-definite matrices via the minimal scaling-rotation framework," ENAR, Atlanta, April 2018.
2. Byungwon Kim, Jörn Schulz, Stephan Huckemann, **Sungkyu Jung**, "Small Sphere Distributions for Directional Data With Application to Medical Imaging," ENAR, Atlanta, April 2018.
3. Brian Rooks and **Sungkyu Jung**, "Averaging symmetric positive-definite matrices via the minimal scaling-rotation framework," European Meeting of Statisticians, Helsinki, Finland, July 2017.

4. Sungwon Lee and **Sungkyu Jung**, “High-dimension Low Sample Size Asymptotics of Canonical Correlation Analysis,” JSM 2015, Seattle, August 2015. (Contributed Talk)
5. Byungwon Kim, Jörn Schulz, Stephan Huckemann, **Sungkyu Jung**, “Small Circle Distributions for Estimation of Rotational Axis from Directional Data,” ASA Pittsburgh Chapter, Spring Banquet, March 2016. (Poster Presentation)
6. Byungwon Kim, Jörn Schulz, Stephan Huckemann, **Sungkyu Jung**, “Small Sphere Distributions for Directional Data With Application to Medical Imaging,” IMS-APRM, Hong Kong, June 2016. (Topic-contributed Session)

### *Presentations as non-presenting co-author*

Presenters are marked by \*. Ph.D. Students are underlined.

1. Joern Schulz\*, Byung Won Kim, Stephan Huckemann, J. S. Marron, Stephen Pizer, **Sungkyu Jung**, “Analysis of rotational deformations from directional data using a parametric and non-parametric approach,” 22nd International Conference on Computational Statistics, Oviedo, Spain, August 2016.
2. Gen Li\* and **Sungkyu Jung**, “Supervised Integrative Principal Component Analysis,” Conference on Statistical Learning and Data Science, Chapel Hill, NC, June 2016.
3. **Sungkyu Jung** and Xingye Qiao\*, “A Statistical Approach to Set Classification by Feature Selection with Applications to Classification of Histopathology Images,” 2014 ICSA-KISS Applied Statistics Symposium, Portland, June 2014.

## Courses taught

Seoul National University (2018–)

Topic: Statistics on Manifolds (326.631A). *Fall 2018*

Applied Statistics (326.520A). *Spring 2019*

Data-driven Statistical Decision Model. *Summer 2018* at Big Data Institute.

University of Pittsburgh (2011–2018)

STAT 1151: Introduction to Probability. *Fall 2011–2015*

STAT 1152: Introduction to Mathematical Statistics. *Spring 2012–2014, 2016*

STAT 1291: Topic—Principles of Data Science. *Fall 2017*

STAT 1301/2300: Statistical Packages. *Fall 2014*

STAT 1632/2640: Intermediate Mathematical Statistics. *Spring 2015–2018*

STAT 2221: Advanced Applied Multivariate Analysis. *Fall 2013, Spring 2015*

STAT 2631: Theory of Statistics. *Fall 2016, Spring 2018*

STAT 3341: Advanced Modern Statistical Computing. *Spring 2017*

University of North Carolina at Chapel Hill (2006–2011)

STOR 155: Introduction to Statistics. *Fall 2008*

## Advising

### *Ph.D. students*

- ◇ Sungwon Lee, Ph.D. 2016, Pitt. “Analysis of variation structure in high-dimensional multi-block data” (2013–2016).  
— Employment: Mathematical statistician at FDA.
- ◇ Byung Won Kim, Ph.D. 2018, Pitt. “Small sphere distributions and related topics in directional statistics” (2013–2018).  
— Employment: Postdoctoral researcher at University of Pittsburgh.
- ◇ Brian Rooks, Ph.D. 2018, Pitt. “Statistical analysis of random symmetric positive definite matrices via eigen-decomposition” (2014–2018).  
— Employment: Postdoctoral researcher at University of Rochester.
- ◇ Xing Gao (2016–), Pitt.  
— Work in progress on “Structured factorizations for multi-block data.”
- ◇ Seo Won Choi (2018–), SNU.

### *Masters students*

- ◇ Sangil Han, SNU, M.S. in Statistics 2020 (expected.)
- ◇ Jaemin Kim, SNU, M.S. in Statistics 2020 (expected.)

### *Doctoral dissertation committee*

- ◇ Wanjie Wang, Carnegie Mellon University, Statistics (Adviser: Jiashun Jin), Ph.D. 2014.
- ◇ Scott Rothenberger, Pitt Statistics (Adviser: Rob Krafty), Ph.D. 2014.
- ◇ Cong Ye, Pitt Statistics (Adviser: David Stoffer), Ph.D. 2015.
- ◇ Yun Zhang, Pitt Statistics (Advisers: Allan Sampson, Kehui Chen), Ph.D. 2016.
- ◇ Qiyao Wang, Pitt Statistics (Adviser: Kehui Chen ), Ph.D. 2017.
- ◇ Yu Liu, Pitt Statistics (Adviser: Zhao Ren), Ph.D. 2018 (expected).
- ◇ John Pleis, Pitt Biostatistics (Adviser: Stewart Anderson), Ph.D. 2018.

### *Masters thesis committee*

- ◇ Andrey Sharapov, Pitt Statistics (Adviser: Stoffer), M.S. 2013.

### *Undergraduate mentoring*

- ◇ Sarah Sullivan, Summer 2012. (Internship. Joint with K. T. Cuenco, Human Genetics, Pitt on matched case-control analysis.)
- ◇ Kelly Cahill, 2015–2016. (Independent Study on R coding.)



## Service

### *Professional activities*

1. **Chair** for topic-contributed session on *Recent Advances in Object Data Analysis*, IMS-APRM, Hong Kong, June 2016.
2. **NSF grant reviewer and panelist** for DMS–Statistics program, 2014.
3. **Organizer and chair** for invited session on *Statistics for nonlinear spaces with applications to biosciences*, the 3rd IMS-APRM, Taipei, Taiwan, 2014.
4. **Co-organizer and chair** for topic-contributed session on *Recent developments on learning methods from manifold data and related theory*, JSM, Montreal, Canada, 2013.
5. **Organizer** for invited session on *Inference for high dimensional data with low sample size*, 59th World Statistics Conference, Hong Kong, China, 2013.
6. **Member**, Institute of Mathematical Statistics, American Statistical Association, Eastern North American Region of International Biometric Society, Korean International Statistics Society and Bernoulli Society.

### *Editorial services*

1. **Associate Editor**, Journal of Nonparametric Statistics, 2017–
2. **Associate Editor**, Journal of Korean Statistical Society, 2014–
3. **Screening Committee member**, Journal of Korean Statistical Society, July–Sep. 2013.
4. **Reviewer** for :  
*The Annals of Statistics, Journal of the Royal Statistical Society, Series B, Journal of the American Statistical Association, Journal of Multivariate Analysis, Statistica Sinica, Biometrika, Journal of Statistical Planning and Inference, Statistical Methods and Applications, Journal of Korean Statistical Society, Methodology and Computing of Applied Probability, Electronic Journal of Statistics, Journal of Nonparametric Statistics, Technometrics, Journal of Acoustic Society of America, IEEE Journal of Biomedical and Health Informatics, IEEE Signal Processing Letters, Scandinavian Journal of Statistics, Environmental and Ecological Statistics, The American Statistician.*  
 Reviewed about 8 rounds of papers per year since 2012.

### *Intramural Services*

- Member**, Dietrich School Tenure Promotion Council. Sep. 1, 2017–
- Elected member**, Dietrich School of Arts and Sciences Council. Sep. 1, 2016–Aug. 31, 2019.
- Course Coordinator** for course scheduling and ancillary budget, Department of Statistics. 2016–2017.
- Chair**, Curriculum review committee, Department of Statistics. 2015–2017.
- Member**, Faculty hiring committee, Department of Statistics. Spring 2013, 2015.
- Member**, Admissions committee, Department of Statistics. Spring 2014, 2015, 2016.
- Member**, Qualifying exam committee, Department of Statistics. 2014–2017.

*Extramural Services*

*Associate Liaison* between University of Pittsburgh and National Institute of Statistical Science, 2015–2018.

*Webmaster*, Pittsburgh Chapter, American Statistical Association, 2014–2017.

*Special Awards Judge* for Intel International Science and Engineering Fair 2015, Pittsburgh.

*Mentor* for Young Generation group of KSEA (Korean-American Scientists and Engineers Association), Pittsburgh Chapter. 2011–2014.