01

Introduction

457.212 Statistics for Civil and Environmental Engineers

Junho Song (junhosong@snu.ac.kr)

SSRG

Structural/System Reliability Group

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Blog – News | Blog – Publications | Blog – Software

Research group website: http://systemreliability.wordpress.com

Junho Song (송준호), PhD

Junho Song, Ph.D.

Junho Song holds a B.S. and M.S. in civil engineering (Seoul National University, Korea) and a Ph.D. in civil & environmental engineering (University of California, Berkeley). Prior to joining the faculty of the Department of Civil and Environmental Engineering at Seoul National University in January, 2014, he worked as a postdoctoral researcher at the University of California at Berkeley (2004–2005), a senior vulnerability engineer at Risk Management Solutions, Inc (2005), and a faculty of the Department of Civil and Environmental Engineering at the University of Illinois at Urbana-Champaign (Assistant Professor: 2005–2011, Associate Professor: 2011–2013, CEE Excellence Faculty Scholar: 2012–2013).

Dr. Song has research interests in structural reliability, reliability of complex systems, random vibrations, earthquake engineering, systematic treatment of uncertainty, and post-hazard performance of lifeline systems. His previous/ongoing research topics include seismic response and reliability of electrical substation equipment and systems; bounds on system reliability; reliability of structural systems under stochastic excitation; multi-scale reliability analysis and updating of complex systems; availability of systems with randomly failing components; probabilistic shear strength models for reinforced concrete beams and beam-column connections; matrix-based system reliability method and applications to bridge network and structural systems; system reliability analyses for earthquake engineering, heavy machines and aircraft structures; systematic treatment of uncertainties in paleo-liquefaction studies; probabilistic fracture analysis of functionally graded materials; post-hazard availability and downtime of lifeline structural systems; and structural condition assessment based on multi-objective optimization.

Dr. Song is a member of the American Society of Civil Engineers (ASCE), and the Earthquake Engineering Research Institute (EERI). He serves as a member of the Probabilistic Methods Committee of ASCE Engineering Mechanics Division, four editorial boards of international journals (International Journal of Steel Structures, ASCE Journal of Structural Engineering, Journal of the Earthquake Engineering Society of Korea, ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems), SC3 subcommittee of International Association for Structural Safety and Reliability (IASSAR), IFIP WG7.5 working group, and Joint Committee on Structural Safety (JCSS). He has been serving the Board of Directors of the International Civil Engineering Risk and Reliability Association (CERRA) since 2011. He also serves as an associate editor ("Optimization & Safety and Reliability") of ASCE Journal of Structural Engineering.

Dr. Song teaches graduate and undergraduate courses in the area of engineering risk & uncertainty, decision & risk analysis, structural reliability, system reliability, random vibrations, and probabilistic loads on structures.

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Junho Song, Ph.D.

Syllabus

457.212 Statistics for Civil & Environmental Engineers

Fall 2015

Instructor: Prof. Junho Song (junhosong@snu.ac.kr, 35-403)

Teaching Assistants: Taeyong Kim (chs5566@snu.ac.kr, 35-421)

Lectures: 2:00-3:15 pm, Tuesdays & Thursdays, 35-223 (in English)

Tutorial: To be announced (if needed)

Office Hours: Junho Song: Q&A after each class or appointment by email
Taeyong Kim: Appointment by email

Important Dates:

Classes begin: September 1
Thanksgiving holiday: September 29 (No Class)
Instructor's business trip: October 6, 8 (No class)
MIDTERM1, in class, October 15 (University Holiday)
MIDTERM2, in class, November 17
Last Day of Class: December 15
FINAL: Thursday, December 17 (3 hrs)

Catalog Description:

Identification and modeling of non-deterministic problems in civil and environmental engineering design and decision making. Development of stochastic concepts and simulation models and their relevance to real design and decision problems in various areas of civil and environmental engineering.

Course Objectives:

The students can describe/use the concepts and methods of probability and statistics that are crucial for solving civil and environmental engineering problems. The students are introduced to a variety of CEE problems through statistical/probabilistic analysis.

Prerequisites: Credits in Calculus I & II required.

Credit: 3 semester hours

Textbook:

Ang, A. H-S., and Wilson, H. Tang, Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering, 2nd edition, Wiley, New York, 2006.

Course Website: eTLcourse website (http://etl.snu.ac.kr/)

Homework:

Weekly assignments and solutions will be posted on the course website at least one week prior to the due date. See the course schedule for the due dates. Turn them in BEFORE the class starts. The homework sets submitted after the class are considered "late" (penalty at least 15%).

Grading: Attendance: 5%, Homework: 25%, Midterm I: 15%, Midterm II: 25%, Final Exam: 30%; Bonus points for active attitudes in class.

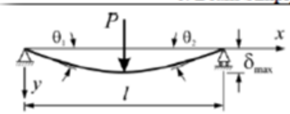
* Your attendance will be checked by using your designated seat location in the classroom, which will be determined by your location on September 8 (Tuesday).

Design of a simple beam bridge

Design of a simple beam bridge

- Problem statement

BEAM DEFLECTION FORMULAS

BEAM TYPE	SLOPE AT ENDS	DEFLECTION AT ANY SECTION IN TERMS OF x	MAXIMUM AND CENTER DEFLECTION
6. Beam Simply Supported at Ends – Concentrated load P at the center			
	$\theta_1 = \theta_2 = \frac{Pl^2}{16EI}$	$y = \frac{Px}{12EI}\left(\frac{3l^2}{4} - x^2\right)$ for $0 < x < \frac{l}{2}$	$\delta_{max} = \frac{Pl^3}{48EI}$
7. Beam Simply Supported at Ends – Concentrated load P at any point			
	$\theta_1 = \frac{Pb(l^2-b^2)}{\ldots}$	$y = \frac{Pbx}{6lEI}(l^2 - x^2 - b^2)$ for $0 < x < a$	$\delta = \frac{Pb(l^2-b^2)^{3/2}}{\ldots}$ at $x = \sqrt{(l^2-b^2)/3}$

- Design criteria & concerns

Design of a simple beam bridge (contd.)

- **Uncertainty** in this problem?
  1) Weight of pedestrians
  2)
  3)
  4)
  5)

- **Uncertainty**, **decision** and **risk**

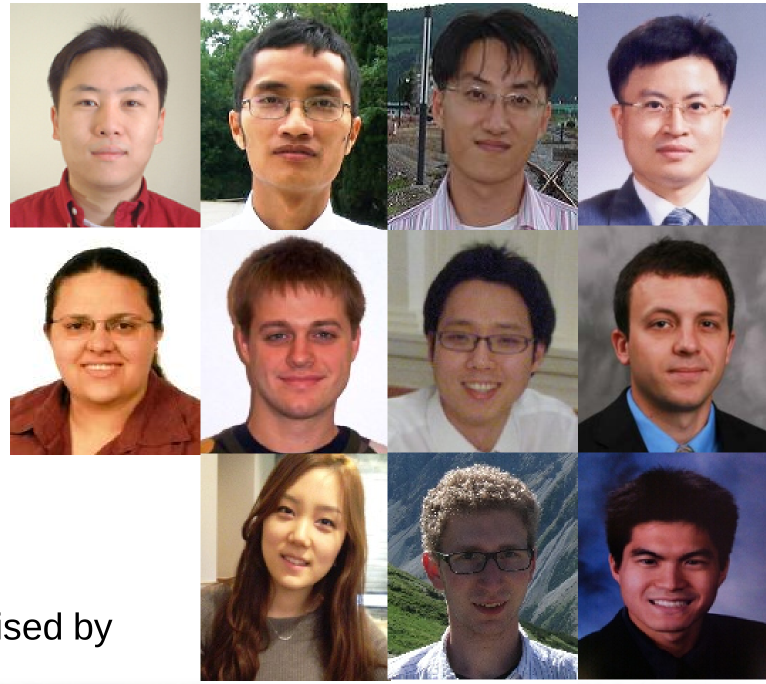
Uncertainties in CEE

- **Inherent** randomness
  - "Aleatoric" uncertainty
  - Physical fluctuation
  - (Can/Can't) be reduced
  - Represented by stochastic models and descriptors

- **Knowledge-based** uncertainty
  - "Epistemic" uncertainty
  - Uncertainty due to the lack of knowledge
  - (Can/Can't) be reduced
    1) Model errors (e.g.)
    2) Statistical errors (e.g.)

Structural/System Reliability Group

University of Illinois (2005~2013)



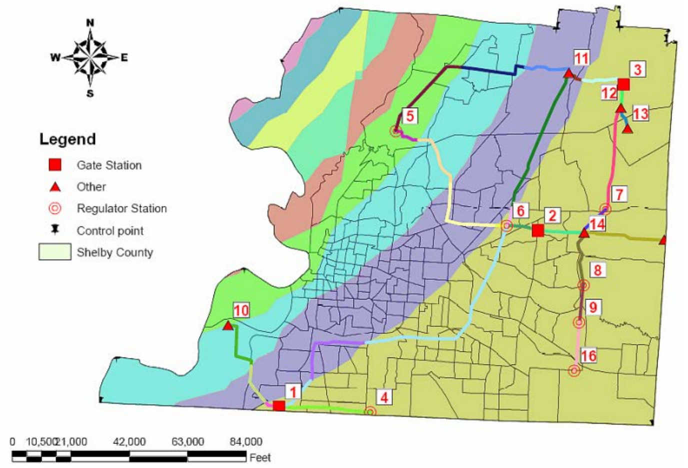
- **PhD (6 graduated):**
  Won Hee **Kang** (Univ. of Western Sydney, Australia),
  Tam H. **Nguyen** (KTP Singapore),
  Young Joo **Lee** (UNIST, Korea),
  Hyun-Woo **Lim** (Ministry of Public Safety and Security, Korea),
  Derya **Deniz** (University of Colorado, Boulder, USA),
  Nolan **Kurtz** (USA)
- **PhD Course**:
  Junho **Chun** (UIUC, co-advised by G. Paulino)
- **MS (4 graduated)**:
  Blake **Andrews** (WJE, USA), Minseo **Kim** (UIUC),
  Reece **Otsuka** (Enercon, USA), Raphael **Stern** (UIUC, co-advised by D. Work)

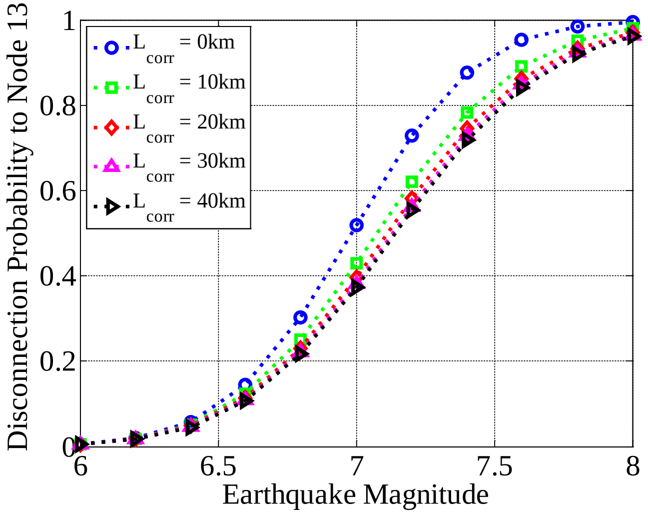
Seoul National University (2014~)

- **PhD Course**:
  Se Hyeok **Lee**(08), Eujeong **Choi**(08)
- **MS/PhD Course**:
  Jieun **Byun**(11), Sang-ri **Yi**(11),
  Jiwhan **Kim**(11)
- **MS Course**:
  Byoung-Sung **Choi**(09), Tae yong **Kim**(10)

I. Lifeline network reliability analysis

- **Uncertainty**
  - Earthquake hazard intensity
  - Performance of structures
- **Risk**
  - Insufficient service or outage
  - Disconnection
- **Solution**
  - Likelihood of network malfunctions
  - Quantify relative importance of network components

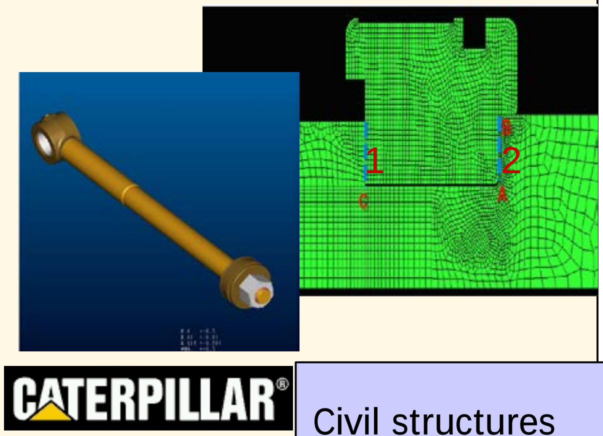




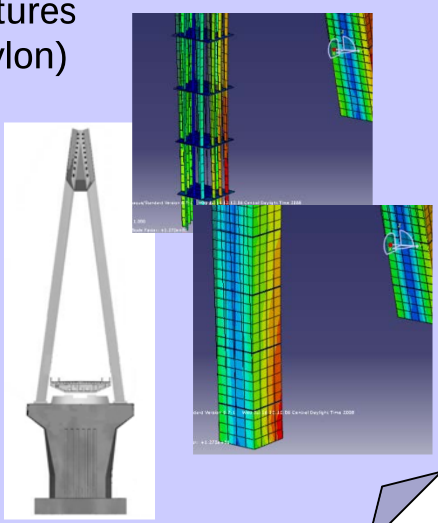
II. Reliability analysis of structures

- **Uncertainty**
  - Material properties
  - Loadings
- **Risk**
  - Structural failures (e.g. yielding)
  - Violate serviceability criteria
- **Solution**
  - Likelihood of structural failures
  - Identify important uncertainties in risk
  - Find how to reduce risk effectively

Mechanical structures
(single-nut piston)

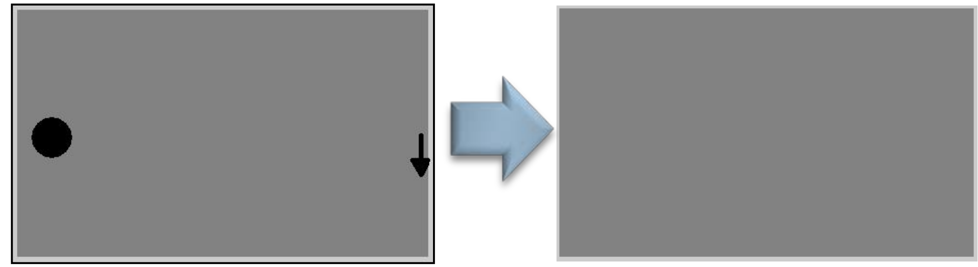


Civil structures
(Bridge pylon)

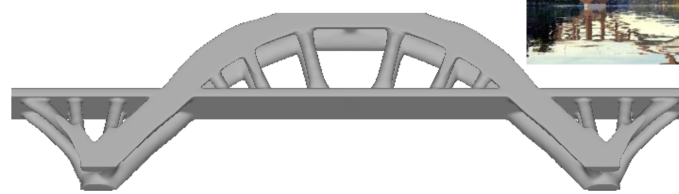


III. Reliability-based design optimization

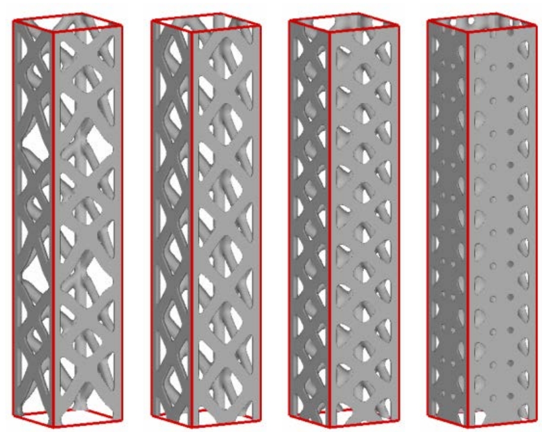
- Uncertainty
  - Material properties
  - Loading (location; intensity)



- Risk
  - Optimal design that is too conservative or unsafe

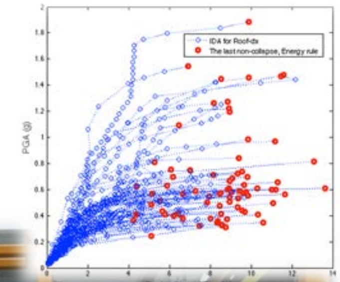


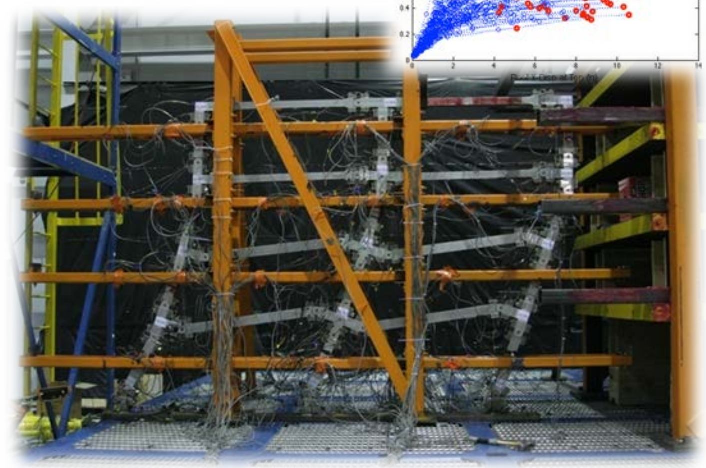
- Solution
  - Optimization algorithm that ensures a required level of reliability (both at component and system levels)



IV. Random vibrations (e.g. by Earthquake)

- Uncertainty
  - Ground motion characteristics
    (Intensity, frequency contents, energy, etc.)
  - Dynamic behavior/failures of structures





- Risk
  - Under- or over-estimating
    the likelihood of structural failures
- Solution
  - Identifying mathematical descriptions of structural failures
  - Design based on accurate prediction of the likelihood of the failures (appropriate level of conservatism)

Schedule

Date	Due	Topics	Read
9/01		Introduction: course organization, uncertainty in CEE, previews	1.2-1.3 Sup 1
9/03		Graphical representation of data: histogram, frequency diagram, scatter plot	
9/08		Numerical descriptors of data: sample mean, standard deviation, skewness	
9/10	HW1	Elements of set theory: sample space, events, Venn diagram, combination of events, operational rules	2.1-2.2
9/15			
(9/17)	HW2	Elements of probability theory: basic axioms, complementary rule, addition rule, conditional probability, multiplication rule	2.3
(9/22)			
9/24	HW3	Total probability theorem & Bayes' rule	
9/29		**Thanksgiving Holiday (no class)**	
10/01	HW4	Definition of random variables, probability distribution functions	3.1
10/06		**Instructor's Business Trip (no class)**	
10/08			
10/13?		Probability distribution functions, partial descriptors	
10/15	HW5	**Midterm I (School Holiday)**	
10/20?		Useful distribution models: normal, lognormal, binomial, Poisson, exponential, beta distributions, etc.	3.2
10/22	HW6		

10/27 10/29	HW7	Multiple random variables: joint and conditional probability distributions, covariance and correlation, conditional mean and variance	3.3 Sup 2
11/03		Monte Carlo simulations, propagation of uncertainty, Central limit theorem	5.2, S3-6
11/05	HW8	Function of random variables: derived probability distributions.	4.2
11/10 11/12	HW9	Mathematical expectation of linear/nonlinear functions	4.3 & S7
11/17		**Midterm II**	
11/19		Statistical inference (1): point estimation - method of moments, method of maximum likelihood	6.1-6.2
11/24			
11/26	HW10	Statistical inference (2): testing of hypothesis	6.3
12/01		Statistical inference (3): interval estimation	6.3-6.4
12/03	HW11	Testing validity of distributions (1): probability papers	7.2
12/08		Testing validity of distributions (2): Chi-square test, K-S test	7.3
12/10	HW12	Regression analysis & correlation analysis.	8.2-8.3
12/15			
12/17	HW13	**Final Exam (3 hrs)**	

Note: The class schedule could be changed during the semester, and the up-to-date version will be available at the course website; The dates in ( ) indicate relocation to 35-316; The dates with “?” indicate possibility of relocation to 35-316.

Course website

Statistics for Civil & Environmental Engineers (001)

Song, Junho Prof.

> Statistics for Civil & Environmental Engineers(2014년도, 2학기, 457.212-001)

Activities

- Boards
- Resources

Course Administration

- Professor screen
- Grades
- Group Member

Summary

- Class Announcements
- Syllabus Version 09.02
- Class Schedule Version 09.02
- Assignments
- Supplementary Materials

Current week course

1 September - 7 September

Class02 (09.04) Note

Graphical Representation of Data

* Please bring (1) a hard copy OR (2) an electronic copy and an electronic device with annotating capability, to the class.

All week course

1 September - 7 September

Class02 (09.04) Note

Graphical Representation of Data

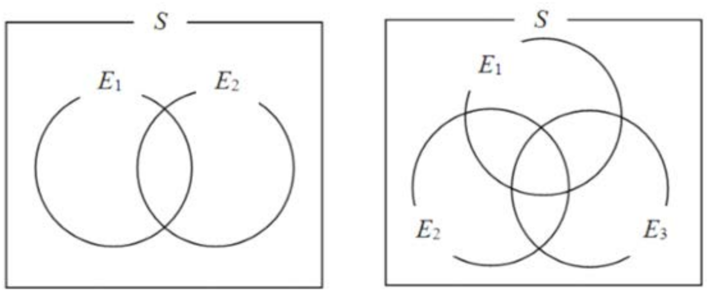
* Please bring (1) a hard copy OR (2) an electronic copy and an electronic device with annotating capability, to the class.

“Print and Bring” in-class materials!

457.212 Statistics for Civil & Environmental Engineers
In-Class Material: Class 05
Elements of Set Theory – Part II (A&T: 2.1-2.2)

3. **Operations** of events

(a) **Union** of events



- **Union** of E_1 and E_2, (   ): An event that contains all the sample points that are in E_1 (/   ) E_2.
- Can be extended to the cases with more than two events - **Union** of $E_1, E_2, \ldots, E_n$, (   ) or (   ):

  An event that contains all the sample points that are in (   ) one of $E_1, E_2, \ldots, E_n$.
- Some notable cases:

  (1) $E \cup S =$

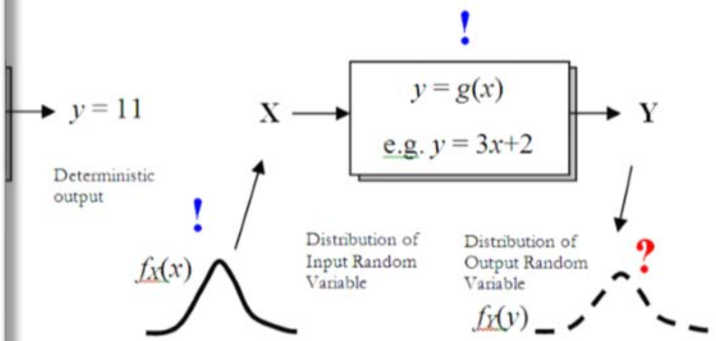
  (2) $E \cup \phi =$

  (3) $E \cup E =$

  (4) If $E_1 \subset E_2$, $E_1 \cup E_2 =$
- CEE examples:

  (1) Concrete production may be hampered by shortage of water (E_1), sand (E_2), gravel (E_3) or cement (E_4).

ics for Civil & Environmental Engineers
n-Class Material: Class 16
n of Random Variables (A&T 4.2)



function of a r.v., $Y = g(X)$

$p_Y(y)$

mass function values of X that satisfy $y = g(X)$

$$(y) = P(Y = y) = \sum_{all\ x_i: y = g(x_i)} p_X(x_i)$$

ete random variable X that follows

x	$p_X(x)$
–1	0.25
0	0.40
1	0.25
2	0.10

functions of X:

z

Looking forward to learning **together**!

Fall 2014 Class of *Statistics for Civil and Environmental Engineers*