MEDICAL IMAGING SYS BSEN414 SEC 001 Fall 2021

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Medical imaging Systems

CLASS IN THE MIDST OF COVID-19

An individual in this course has a documented need for face coverings to be required in this course. Without divulging personal or identifying information, such a documented need might be that a member of their household is unable to be vaccinated or has a health condition that makes vaccines less effective for them. As a result, the College of Engineering has determined that face coverings will be required in this course. If you are unwilling to comply with this requirement, please visit with your advisor about different sections or possible alternative courses that you might take in lieu of this one.

Class Time/Place:
TR 11:00 AM – 12:15 PM
Rm. 112 L.W. Chase Hall

Textbooks:
Medical Imaging – Signals and Systems, 2nd ed.
Prince, J. Links (Prentice-Hall)

Note: This text provides great, supplementary information for the course and provides a different framework for describing the content discussed in class. There will be homework problems assigned from the book. However, if you can get the homework questions from a classmate, the book is not a requirement to pass the course, but is a useful tool in deeper understanding of the material.

Instructor:
Dr. Forrest Kievit

262 Morrison Center
Office hours: TBA + drop in or by appointment, fkievit2@unl.edu

Course Description:

Course Description:
This course will cover the underlying physics, basic instrumentation, and signal analysis of several biomedical and biological imaging modalities. MRI, X-ray (radiography), CT (computed tomography), nuclear medicine, ultrasound, fluorescence, and the human visual system will be studied. Linear systems theory and relevant math will be reviewed. Imaging concepts such as resolution, point spread function, and diffraction will be covered. The information content in images applicable to biological systems will be taught. (Although some MATLAB projects will be assigned, this is not a digital image processing course).

Course Objectives:

Having successfully completed this course, students should be able to:

- Comprehend the application of physics and mathematics to the design of medical imaging systems (ABET 1, 2)
- Apply standard imaging quality parameters to the analysis of medical images (ABET 1, 2, 6, 7)
- Identify the contributions of engineers to a state-of-the-art medical imaging facility (ABET 2, 7)

ABET Criterion 3 outcomes:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic
3. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
4. An ability to acquire and apply new knowledge as needed, using appropriate learning

Professionalism:
Students will be graded on professionalism during class time and in interacting with the instructor and TAs and includes attendance, punctuality, participation, activities during class time, etc. This does not mean you cannot have fun and joke around during class as you will find I do, but this fun should be appropriate and respectful. Attendance is always expected and may be taken at any time, unless a prior arrangement for an excused absence has been made with the instructor. If you have an upcoming excused absence planned, please notify the instructor prior to the absence. Make-up exams and homework will not be given.

Class Procedures:

- Scheduled classes. Class begins *promptly* at 11:00 AM.
- Computer exercises (using MATLAB) will be assigned

- Computer exercises (using MATLAB) will be assigned.
- Announcements may be given by email or by Canvas – **you are responsible for checking Canvas regularly and having a valid email address (who doesn't have an email address these days?!)**

Grading:

Homework (approximately biweekly)*	20%
Experiential Learning Activities	20%
Tests (2)	30%
Final	20%
Intangibles (attendance, punctuality, participation, activities during class time, etc.)	10%

*For students taking 814, the term project will take the place of graded homework assignments.

Points (*x*)	**Final Grade**
x ~> 90, rarely makes minor mistakes in HW and exams	**A range (A-, A, A+)**
80 ~< x ~< 90, rarely makes major mistakes in HW and exams	**B range (B-, B, B+)**
70 ~< x ~< 80, often makes major mistakes in HW and exams	**C range (C-, C, C+)**
60 ~< x ~< 70, major mistakes are dominant in HW and exams	**D range (D-, D, D+)**
x ~< 60, showed minimal effort	**F**

Academic Honesty:

Academic honesty is essential to the existence and integrity of an academic institution. The responsibility for maintaining that integrity is shared by all members of the academic community. The

for maintaining that integrity is shared by all members of the academic community. The University's **Student Code of Conduct** (http://stuafs.unl.edu/DeanofStudents/Student%20Code%20of%20Conduct%20May%20Rev%202014%20a.pdf addresses academic dishonesty. Students who commit acts of academic dishonesty are subject to disciplinary action and are granted due process and the right to appeal any decision. The BSE Department process for grade and academic dishonesty appeals can be found at **http://bse.unl.edu/academicadvising-index** (http://bse.unl.edu/academicadvising-index). Students are encouraged to contact the instructor for clarification of these guidelines if they have questions or concerns."

Services for Students:

The University strives to make all learning experiences as accessible as possible. If you anticipate or experience barriers based on your disability (including mental health, chronic or temporary medical conditions), please let me know immediately so that we can discuss options privately. To establish reasonable accommodations, I may request that you register with Services for Students with Disabilities (SSD). If you are eligible for services and register with their office, make arrangements with me as soon as possible to discuss your accommodations so they can be implemented in a timely manner. SSD contact information: 232 Canfield Admin. Bldg.; 402-472-3787; **acontreras3@unl.edu** (mailto:acontreras3@unl.edu).

UNL offers a variety of options to students to aid them in dealing with stress and adversity. Counseling and Psychological & Services (CAPS) is a multidisciplinary team of psychologists and counselors that works collaboratively with Nebraska students to help them explore their feelings and thoughts and learn helpful ways to improve their mental, psychological and emotional well-being when issues arise. CAPS can be reached by calling 402-472-7450. Big Red Resilience & Well-Being provides one-on-one well-being coaching to any student who wants to enhance their well-being. Trained well-being coaches help students create and be grateful for positive experiences, practice resilience and self-compassion, and find support as they need it. BRRWB can be reached by calling 402-472-8770.

Background of your instructor:

Dr. Forrest Kievit is an Assistant Professor of Biological Systems Engineering (40% teaching, 50% research, 10% service) and started at the University of Nebraska in 2016. Dr. Kievit earned his B.S. in Bioengineering (2007) and Ph.D. in Materials Science and Engineering (2011), both at the University of Washington, followed by postdoctoral and research faculty positions in the Neurological Surgery

Department. His research involves developing nanoparticle-based delivery vehicles for transport into the brain for more effective brain injury treatments. This stems from his career goal to help translate a nanomedicine into clinical use to improve the survival and quality of life of neurosurgery patients. The vast majority of Dr. Kievit's research has focused on nanoparticle-mediated delivery of therapeutics into the brain. Looking forward, he plans to continue developing nanoparticles that will allow for greater

flexibility in therapeutic payload and disease targeting.

https://kievit.unl.edu/welcome (https://kievit.unl.edu/welcome)

Emergency Response Information:

- **Fire Alarm (or other evacuation):** In the event of a fire alarm: Gather belongings (Purse, keys, cellphone, N-Card, etc.) and use the nearest exit to leave the building. Do not use the elevators. After exiting notify emergency personnel of the location of persons unable to exit the building. Do not return to building unless told to do so by emergency personnel.
- **Tornado Warning:** When sirens sound, move to the lowest interior area of building or designated shelter**.** Stay away from windows and stay near an inside wall when possible.
- **Active Shooter**
  - **Evacuate:** if there is a safe escape path, leave belongings behind, keep hands visible and follow police officer instructions.
  - **Hide out:** If evacuation is impossible secure yourself in your space by turning out lights, closing blinds and barricading doors if possible.
  - **Take action**: As a last resort, and only when your life is in imminent danger, attempt to disrupt and/or incapacitate the active shooter.
- **UNL Alert:** Notifications about serious incidents on campus are sent via text message, email, unl.edu website, and social media. For more information go to: http://unlalert.unl.edu (http://unlalert.unl.edu) .
- Additional Emergency Procedures can be found here: http://emergency.unl.edu/doc/Emergency_Procedures_Quicklist.pdf (http://emergency.unl.edu/doc/Emergency_Procedures_Quicklist.pdf)

Course Summary:

Date	Details	Due
Tue Aug 24, 2021	Introduction, Linear systems review (https://canvas.unl.edu/calendar?event_id=299554&include_contexts=course_113302)	11am to 12:15pm
Thu Aug 26, 2021	Linear systems review, imaging (https://canvas.unl.edu/calendar?event_id=299555&include_contexts=course_113302)	11am to 12:15pm

Date	Details	Due
Tue Aug 31, 2021	Linear systems review (https://canvas.unl.edu/calendar?event_id=299556&include_contexts=course_113302)	11am to 12:15pm
Thu Sep 2, 2021	X-ray radiography (https://canvas.unl.edu/calendar?event_id=299548&include_contexts=course_113302)	11am to 12:15pm
	Bonus Assignment 0 (https://canvas.unl.edu/courses/113302/assignments/1050794)	due by 11am
Tue Sep 7, 2021	X-ray radiography (https://canvas.unl.edu/calendar?event_id=299547&include_contexts=course_113302)	11am to 12:15pm
Thu Sep 9, 2021	no class, Dr. K in virtual meeting (https://canvas.unl.edu/calendar?event_id=299553&include_contexts=course_113302)	11am to 12:15pm
	Homework 1 (https://canvas.unl.edu/courses/113302/assignments/1050797)	due by 9:05pm
Tue Sep 14, 2021	X-ray radiography (https://canvas.unl.edu/calendar?event_id=299545&include_contexts=course_113302)	11am to 12:15pm
Thu Sep 16, 2021	X-ray radiography (https://canvas.unl.edu/calendar?event_id=299546&include_contexts=course_113302)	11am to 12:15pm
Tue Sep 21, 2021	Computed tomography (https://canvas.unl.edu/calendar?event_id=299543&include_contexts=course_113302)	11am to 12:15pm
Thu Sep 23, 2021	Computed Tomography (https://canvas.unl.edu/calendar?event_id=299891&include_contexts=course_113302)	11am to 12:15pm
	Homework 2 (https://canvas.unl.edu/courses/113302/assignments/1050798)	due by 9:09pm

Date	Details	Due
Tue Sep 28, 2021	Computed Tomography (https://canvas.unl.edu/calendar?event_id=299544&include_contexts=course_113302)	11am to 12:15pm
Thu Sep 30, 2021	CT Lab (https://canvas.unl.edu/calendar?event_id=299892&include_contexts=course_113302)	11am to 12:15pm
Sat Oct 2, 2021	Homework 3 (https://canvas.unl.edu/courses/113302/assignments/1050799)	due by 12:08pm
Tue Oct 5, 2021	CT Lab (https://canvas.unl.edu/calendar?event_id=299893&include_contexts=course_113302)	11am to 12:15pm
Thu Oct 7, 2021	No class, Dr. K and Evan at BMES (https://canvas.unl.edu/calendar?event_id=299530&include_contexts=course_113302)	11am to 12:15pm
Tue Oct 12, 2021	Test #1 (https://canvas.unl.edu/calendar?event_id=299531&include_contexts=course_113302)	11am to 12:15pm
	Test 1 (https://canvas.unl.edu/courses/113302/assignments/1050813)	due by 12:15pm
Thu Oct 14, 2021	Nuclear Medicine (https://canvas.unl.edu/calendar?event_id=299536&include_contexts=course_113302)	11am to 12:15pm
Fri Oct 15, 2021	CT Lab (https://canvas.unl.edu/courses/113302/assignments/1051549)	due by 11:59pm
Tue Oct 19, 2021	Nuclear Medicine (https://canvas.unl.edu/calendar?event_id=299535&include_contexts=course_113302)	11am to 12:15pm
Thu Oct 21, 2021	MRI (https://canvas.unl.edu/calendar?event_id=299532&include_contexts=course_113302)	11am to 12:15pm

Date	Details	Due
	Homework 4 (https://canvas.unl.edu/courses/113302/assignments/1050800)	due by 11:13pm
Tue Oct 26, 2021	MRI (https://canvas.unl.edu/calendar?event_id=299537&include_contexts=course_113302)	11am to 12:15pm
Thu Oct 28, 2021	MRI (https://canvas.unl.edu/calendar?event_id=299533&include_contexts=course_113302)	11am to 12:15pm
Tue Nov 2, 2021	MRI Lab (https://canvas.unl.edu/calendar?event_id=299779&include_contexts=course_113302)	11am to 12:15pm
	Homework 5 (https://canvas.unl.edu/courses/113302/assignments/1050801)	due by 11:02pm
Thu Nov 4, 2021	MRI Lab (https://canvas.unl.edu/calendar?event_id=299894&include_contexts=course_113302)	11am to 12:15pm
Tue Nov 9, 2021	Test #2 (https://canvas.unl.edu/calendar?event_id=299557&include_contexts=course_113302)	11am to 12:15pm
	Test 2 (https://canvas.unl.edu/courses/113302/assignments/1050814)	due by 12:15pm
	Homework 7 (https://canvas.unl.edu/courses/113302/assignments/1050803)	due by 11:04pm
Thu Nov 11, 2021	Ultrasound (https://canvas.unl.edu/calendar?event_id=299542&include_contexts=course_113302)	11am to 12:15pm
Fri Nov 12, 2021	MRI Lab (https://canvas.unl.edu/courses/113302/assignments/1051550)	due by 11:59pm
Tue Nov 16, 2021	Ultrasound (https://canvas.unl.edu/calendar?event_id=299540&include_contexts=course_113302)	11am to 12:15pm

Date	Details	Due
	Homework 6 (https://canvas.unl.edu/courses/113302/assignments/1050802)	due by 11:24pm
Thu Nov 18, 2021	Ultrasound (https://canvas.unl.edu/calendar?event_id=299539&include_contexts=course_113302)	11am to 12:15pm
Tue Nov 23, 2021	Ultrasound Lab (https://canvas.unl.edu/calendar?event_id=299896&include_contexts=course_113302)	11am to 12:15pm
Thu Nov 25, 2021	Gobble gobble (https://canvas.unl.edu/calendar?event_id=299538&include_contexts=course_113302)	12am
Tue Nov 30, 2021	Ultrasound Lab (https://canvas.unl.edu/calendar?event_id=299897&include_contexts=course_113302)	11am to 12:15pm
Thu Dec 2, 2021	Fluorescence imaging (https://canvas.unl.edu/calendar?event_id=299549&include_contexts=course_113302)	11am to 12:15pm
	Human visual systems (https://canvas.unl.edu/calendar?event_id=299551&include_contexts=course_113302)	11am to 12:15pm
Fri Dec 3, 2021	Ultrasound Lab (https://canvas.unl.edu/courses/113302/assignments/1051551)	due by 11:59pm
Tue Dec 7, 2021	Graduate Presentations (https://canvas.unl.edu/calendar?event_id=299898&include_contexts=course_113302)	11am to 12:15pm
Thu Dec 9, 2021	Review and comparison (https://canvas.unl.edu/calendar?event_id=299780&include_contexts=course_113302)	11am to 12:15pm
Mon Dec 13, 2021	Final Exam (https://canvas.unl.edu/courses/113302/assignments/1050795)	due by 10am
Thu Dec 16, 2021	Term presentation (https://canvas.unl.edu/courses/113302/assignments/1051754)	due by 11am

Date	Details	Due
	10 - Point Source Geometry (https://canvas.unl.edu/courses/113302/assignments/1050773)	
	11 - Detecting X-rays (https://canvas.unl.edu/courses/113302/assignments/1050774)	
	12 - Intro to CT (https://canvas.unl.edu/courses/113302/assignments/1050775)	
	13 - Slices and Projections (https://canvas.unl.edu/courses/113302/assignments/1050776)	
	14 - Reconstruction Methods (https://canvas.unl.edu/courses/113302/assignments/1050777)	
	15 - Intro to backprojection (https://canvas.unl.edu/courses/113302/assignments/1050778)	
	16 - Backprojection Corrections (https://canvas.unl.edu/courses/113302/assignments/1050779)	
	17 - Intro to Nuclear Medicine (https://canvas.unl.edu/courses/113302/assignments/1050780)	
	18 - Detecting Gamma Rays (https://canvas.unl.edu/courses/113302/assignments/1050781)	
	19 - PET imaging (https://canvas.unl.edu/courses/113302/assignments/1050782)	
	20 - Intro to MRI (https://canvas.unl.edu/courses/113302/assignments/1050783)	
	7 - Projection Radiography (https://canvas.unl.edu/courses/113302/assignments/1050790)	
	8 - Producing X-rays (https://canvas.unl.edu/courses/113302/assignments/1050791)	

Date	Details	Due
	9 - X-ray/body interactions (https://canvas.unl.edu/courses/113302/assignments/1050792)	
	Bonus Assignment (https://canvas.unl.edu/courses/113302/assignments/1050793)	
	Class format (https://canvas.unl.edu/courses/113302/assignments/1050772)	
	Lecture 1 - Intro to course concepts (https://canvas.unl.edu/courses/113302/assignments/1050805)	
	Lecture 2 - Review of Signals and Systems, 2D signals (https://canvas.unl.edu/courses/113302/assignments/1050806)	
	Lecture 3 - Commonly Used Functions (https://canvas.unl.edu/courses/113302/assignments/1050807)	
	Lecture 4 - Linear Systems (https://canvas.unl.edu/courses/113302/assignments/1050808)	
	Lecture 5 - Fourier Analyses (https://canvas.unl.edu/courses/113302/assignments/1050809)	
	Lecture 6 - Discrete Functions (https://canvas.unl.edu/courses/113302/assignments/1050810)	
	Professionalism (https://canvas.unl.edu/courses/113302/assignments/1050811)	
	Roll Call Attendance (https://canvas.unl.edu/courses/113302/assignments/1050812)	