Karim Kadry

kkadry@mit.edu

EDUCATION

Massachusetts Institute of Technology , Cambridge, MA Sep 2021-Present
Ph.D in Medical Engineering and Medical Physics (*Concentration*: Computer Science)

- Thesis title: Synthetic Cardiovascular Anatomy Generation for Virtual Interventions Using Diffusion Models (Advisor: Elazer Edelman)

Ecole Polytechnique Fédéral de Lausanne , Lausanne, Switzerland Mar 2021
Master of Science (M.Sc.) in Life Sciences Engineering

- Thesis title: Computational Biomechanics of Coronary Artery Digital Twins (Advisors: Elazer Edelman and Nikolaos Stergiopulos)

American University in Cairo, Cairo, Egypt Jun 2018
Bachelor of Science (B.Sc.) in Mechanical Engineering

- Thesis title: Safer Pin Design for Head Immobilization Devices (Advisor: Khalil El-Khodary)

Bachelor of Science (B.Sc.) in Physics

RESEARCH EXPERIENCE

Institute for Medical Engineering and Science, Massachusetts Institute of Technology, United States of America

PhD Student, Edelman Lab Sep 2021 –Present

Project: Computational modeling of percutaneous coronary interventions

- Developed a morphological interpolation module to enable automatic construction of 3D multi-material models of coronary arteries from 2D segmentation maps.
- Created digital twins of calcified coronary arteries before and after intravascular lithotripsy to investigate the effect of lithotripsy-induced calcium fracture on stent expansion.
- Designed and co-supervised master thesis project of R.S to further develop automatic model creation of coronary digital twins.
- Designed and supervised master thesis project of J.S to develop biomechanical simulations of virtual stent angioplasty and virtual balloon angioplasty for coronary arteries.

Project: Multi-modal analysis of coronary artery imaging modalities using computer vision

- Trained convolutional neural networks for the multi-label segmentation of coronary morphology from optical coherence tomography images.
- Developed a non-rigid spatial transform module to model intravascular catheter motion distortion during the imaging pullback.
- Formulated and benchmarked an automatic algorithm for morphology-based registration of intravascular images and coronary computed tomography to achieve multi-modal data fusion.
- Designed and supervised master thesis project of S.A to further develop segmentation and registration modules to investigate the use of multi-modality coronary imaging for self-supervised learning .
- Designed and co-supervised master thesis project of K.P to develop multi-modality informed computational models of coronary anatomy to investigate biomechanical interactions between calcium and 3D arterial curvature.

Project: Synthetic cohort generation for in-silico clinical trials through denoising diffusion models

- Developed a latent diffusion model to generate or edit 3D multi-material segmentations of cardiovascular anatomy with morphological control.
- Characterized the anatomic bias introduced by diffusion-model based generation and editing techniques.
- Leveraged topological loss functions to generate synthetic coronary arteries that are viable for numerical simulations.
- Designed and currently supervising undergraduate research project of S.G to conduct a multiscale analysis of cardiac anatomy generated by latent diffusion models.

RESEARCH EXPERIENCE

Research Assistant, Master Thesis Project, Edelman Lab — Jun 2020 – Sep 2021

- Created semi-automatic workflow for the generation of simulation-ready multi-material 3D artery models from stacked 2D segmentations.
- Developed an automatic adaptive mesh refinement module for multi-component artery models.
- Conducted biomechanical simulations of patient-specific atherosclerotic arteries on a computing cluster to examine the effect of atherosclerotic anatomy on arterial wall stress.

Department of Mechanical Engineering, Ecole Polytechnique Féderal de Lausanne, Switzerland

Research Assistant, Laboratory of Hemodynamics and Cardiovascular Tech. Sep 2018 – Sep 2020

- Adapted a lumped parameter model of cardiovascular hemodynamics to incorporate left ventricular dysfunction resulting from abnormalities in active and passive relaxation.
- Computationally analyzed the effect of delayed active relaxation and increased ventricular stiffness on both valvular and aortic hemodynamics.
- Replicated the hemodynamic profiles for each stage of left ventricular diastolic dysfunction.

Department of Bioengineering, Imperial College London, United Kingdom

Visiting Research Intern, Moore Research Group — Jul 2019 – Sep 2019

- Developed a finite element solver to model diffusion, advection, and binding for multiple species of chemokine on a 1D network within the lymph node.
- Coupled the finite element solver to an agent-based model of dendritic cell chemotaxis to model cellular dynamics.
- Developed a generative model of transport networks within the lymph node to investigate how cellular dynamics change with network topology.

Industrial Engineering Department, University of Pittsburgh, United States of America

Visiting Research Intern, Bedewy Research Group — Apr 2017 – Sep 2017

- Derived a relationship between mechanical properties of cortical bone and age.
- Developed age-dependent parametric model of multi-layered skull geometry.
- Conducted FEM simulations of neurosurgical pin penetration on computing cluster in order to investigate the interaction between axial penetration depth, transverse force stability, and age.

Mechanical Engineering Department, American University in Cairo, Egypt

Research Assistant, Khodary Research Group — Feb 2016 – Nov 2016

- Meshed the geometry of coarctated aortic arches before and after corrective operations for computational fluid dynamics simulations.
- Conducted an analysis of simulation results, recording blood flow, shear stress, oscillatory shear index and velocity profiles at several sections throughout the aortic arch.

Mechanical Engineering Department, American University in Cairo, Egypt

Student, Bachelor Thesis Project — Sep 2017 – Jun 2018

- Planned and created experimental setup and protocols for mechanical testing of pins.
- Aided in modelling the pin-skull interaction using FEM and designing appropriate pin shapes to minimize risk of skull penetration.

MENTORSHIP EXPERIENCE

Designed research projects for and mentored the following students:

- Shreya Gupta (UROP conducted at MIT): “Multiscale Analysis of Diffusion Models Trained on Cardiac Anatomy” (2023-present)
- Kehan Pan (M.Sc thesis conducted at Brigham and Women’s Hospital): “Evaluating The Biomechanical Interaction Between Vessel Curvature and Calcium Morphology in Coronary Arteries” (2023-2023)
- Sohee Ahn (M.Eng research and thesis for MIT): “Multimodal Data Fusion for Deep Learning Applications in Intracoronary Image Segmentation” (2022-2023)
- Jonas Sogbadji (M.Sc research and thesis for MIT): “Impact of lesion preparation-induced calcium fractures in vascular intervention for atherosclerotic disease: in silico assessment” (2022-2023)
- Ross Straughn (M.Sc thesis conducted at Brigham and Women’s Hospital): “Fully Automated Construction of Three-dimensional Finite Element Simulations from Optical Coherence Tomography” (2022-2023)

PUBLICATIONS

Note: Equal contributions indicated by †

- **Kadry, K**, et al. (2023) Evaluating Diffusion Models as Anatomic Generators for Virtual Interventions. *In Preparation*
- Straughn, R†, **Kadry, K**.†, et al. (2023) Fully Automated Construction of Three-dimensional Finite Element Simulations from Optical Coherence Tomography. *Computers in Biology and Medicine, 107341*
- **Kadry, K.**, et al. (2022). Morphology-based non-rigid registration of coronary computed tomography and intravascular images through virtual catheter path optimization. arXiv preprint arXiv:2301.00060. *Under Review*
- **Kadry K**., et al. (2021). A platform for high-fidelity patient-specific structural modelling of atherosclerotic arteries: from intravascular imaging to three-dimensional stress distributions. Journal of the Royal Society Interface, 18(182), 20210436.
- **Kadry, K.**, et al. (2020). Biomechanics of diastolic dysfunction: a one-dimensional computational modeling approach. American Journal of Physiology-Heart and Circulatory Physiology, 319(4), H882-H892.
- Abdulhafez, M., **Kadry, K.**, et al. (2018, June). Biomechanical root cause analysis of complications in head immobilization devices for pediatric neurosurgery. In International Manufacturing Science and Engineering Conference (Vol. 51357, p. V001T05A007). American Society of Mechanical Engineers.

ACADEMIC HONORS & SCHOLARSHIPS

- Termeer Fellowship of Medical Engineering and Science (2023-2024)
- Undergraduate scholarship for outstanding academic achievement from the American University in Cairo (2013 – 2018)
- Presidential Scholarship from the Egyptian Ministry of Foreign Affairs (2013 –2018)

WORK EXPERIENCE

Novostia, Neuchatel, Switzerland
Engineering Intern, Support to CTO — Jan 2020 – Jul 2020

- Supervised development activities jointly with CTO for a novel trileaflet mechanical heart valve.
- Synthesized in-vitro testing documentation (recent and past).
- Co-supervised in-vitro/development activities which includes manufacturing, 3D measurements, roughness characterization, air leak testing, accelerated wear tests, hydrodynamic testing, and bio-compatibility studies.
- Co-supervised experimental and simulation activities (FSI,PIV,etc) with external contractors and academics.
- Ran preliminary hemocompatibility experiments to inform polishing and manufacturing.

Tagaddod, Cairo, Egypt
Intern, Research & Development Division — Jan 2017 – Feb 2017

- Researched potential production processes to determine an economic method of producing hydrotreated vegetable oil without hydrogen.
- Planned and tested experimental apparatus to produce the required product.

SCIENTIFIC DISCLOSURES

- Farhad Nezami, Elazer Edelman, **Karim Kadry**, Ross Straughn, "A Fully Automated Platform to Enable 3-Dimensional Structural Simulations of Coronary Arteries using Intravascular images", granted by Brigham and Women's Hospital (2022), Invention Number 2023-026.

TECHNICAL SKILLS

Programming:Python (Excellent), MATLAB (Excellent), C++ (Basic), and R (Basic)
CAD: Solidworks, AutoCAD, ANSYS Spaceclaim, Fusion 360
CFD: ANSYS CFX (ICEM and CFD-Post)
FEM: ANSYS APDL, ANSYS WB, ABAQUS, COMSOL
Other: Linux