BIOGRAPHICAL SKETCH

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NAME: Magin, Richard Lloyd

eRA COMMONS USER NAME (credential, e.g., agency login): RICHARDMAGIN

POSITION TITLE: Distinguished Professor, Department of Bioengineering

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Georgia Institute of Technology, Atlanta, GA	B.S.	06/1969	Physics
Georgia Institute of Technology, Atlanta, GA	M.S.	06/1972	Physics
University of Rochester, Rochester, NY	Ph.D.	06/1976	Biophysics

A. Personal statement.

I have directed the Diagnostic Magnetic Resonance Imaging Laboratory (DML) at UIC since 1999, which specializes in the development of new MR imaging technology based on selective contrast enhancement due to local tissue relaxation, diffusion and mechanical stiffness. I am currently focused on two related efforts, the design of high b-value diffusion acquisition sequences (DAS) to identify sub-voxel tissue structure and the development of high-resolution magnetic resonance elastography (MRE) for assessing tissue stiffness. The goal of DAS, sponsored by the NIH through an R01 grant, is to develop models and methods to assess how the diffusion of water in complex, heterogeneous biological tissue can be used to identify novel biomarkers for tissue porosity and tortuosity. We are focused on using fractal and fractional order models incorporating multi-scale modeling to identify key features of tissue organization and interconnectivity. The outcomes of this work impact tissue engineering, tumor detection and treatment assessment. My work in MRE, supported by grants from NIH and NSF, involves vibrating a subject or specimen in an MRI to produce an image of the propagating vibratory waves. From these images, one can quantify tissue stiffness (from measurements of the observed wavelength) and damping (from measurements of the acoustic signal decay), properties directly associated with the shear modulus and viscoelasticity of the tissue – both of which are often altered by disease or trauma. MRE potentially has a much larger dynamic range (typically three orders of magnitude in the shear modulus) than relaxation or diffusion measurements, leading to new applications for identifying anomalies in virtually every organ and soft tissue region in the body. When coupled with advanced multi-scale modeling approaches, for example using fractal and fractional calculus methods and combined with diffusion tensor imaging (DTI), it can be used to reconstruct of the mechanical properties of both isotropic and anisotropic tissues, from the MR phase images. Such data provide noninvasive, microscopic information from living tissue, which corresponds to changes heretofore discernible only from optical microscopic measurements.

I was a founding member of the MR Engineering Study Group of the International Society for Magnetic Resonance in Medicine (ISMRM) and have over 30 years experience in the development of MR hardware and software. I am the author of more than 200 peer-reviewed technical papers, monographs, book chapters and the book, Fractional Calculus in Bioengineering (Redding, CT, Begell House, 2006). This work has been supported by grants from the National Institutes of Health and by the National Science Foundation. My research interests and expertise, as described above, will directly benefit the proposed research, wherein my role is focused on the design and application of MRE and DTI measurements on multi-scale muscle phantoms and *in vivo* muscle.

B. Positions and Honors.

Positions and Employment

1) The University of Illinois at Chicago, Department of Bioengineering. Chicago, Illinois. Distinguished Professor 2009 – present.
2) The University of Illinois at Chicago, Department of Bioengineering. Chicago, Illinois. Professor & Head: 1998 – 2009.
3) The University of Illinois at Champaign-Urbana, Department of Electrical and Computer Engineering. Champaign, Illinois. Professor: 1990 – 2009. Associate Professor: 1984 – 1990. Assistant Professor: 1979 – 1984.
4) National Institutes of Health, Laboratory of Chemical Pharmacology, Bethesda, MD, Research Biophysicist: 1976 – 1979.
5) Georgia Institute of Technology, Engineering Experiment Station, Atlanta Georgia, Assistant Research Engineer: 1972 – 1976.

Selected Honors and Awards

1) **Distinguished Professor of Bioengineering at UIC (2010).**
2) **Fulbright Award for Teaching and Research at the Technical University of Kosice, Kosice, Slovakia (2005 – 2006).**
3) **Fellow of the American Institute for Medical and Biological Engineering (2001).**
4) **Fellow of the Institute of Electrical and Electronic Engineering (1996)**.

Other Experience and Professional Activities

1) *Associate Editor*, IEEE Transactions on Biomedical Engineering (6/87 – 6/03).
2) *Editor*, Critical Review of Biomedical Engineering (6/00 – 6/08).
3) *Editorial Board Member*, Magnetic Resonance Engineering (7/00 – present).
4) *Editorial Board Member*, Fractional Calculus and Applied Analysis (9/10 – present).
5) *Editorial Board Member*, Journal of Applied Nonlinear Dynamics (9/12 – present).
6) *Editorial Board Member*, Discontinuity, Nonlinearity and Complexity (9/14 – present).
7) *Editorial Board Member*, Acta Mechanica Slovaca (9/08 – present).
8) *Member,* International Society for Magnetic Resonance in Medicine (ISMRM), IEEE and Biomedical Engineering Society.

Predoctoral & Postdoctoral Student Mentorship (UIC)

1) Tarek El-Bialy, PhD 2001. Postdoctoral appointment: 2001 – 2002. *Present position: Faculty of Medicine and Dentistry, University of Alberta, Canada.*
2) Samuel C. Grant, PhD, 2001, *Placement: Florida State University, Professor.*
3) Sertac Eroglu, PhD, 2002, *Placement: Kosh University, Turkey, Professor.*
4) Barjor Gimi, PhD, 2002, *Placement: Dartmouth Unveristy, Assoc Professor.*
5) Shadi Othman, PhD, 2004, *Placement: University of Nebraska, Asoc. Professor.*
6) Huihui Xu, PhD 2005, *Placement: Pacific University, Assist. Professor.*
7) Suraj Serai, PhD 2007, *Placement: Cincinnati Children's Hospital, Assoc. Professor.*
8) Weiguo Li, PhD 2010, *Placement: University of Illinois at Chicago, Research Professor.*
9) Xu Feng, PhD 2011, *Placement: Radia Inc., PS, Seattle, WA, Advanced Clinical Image Analyst.*
10) Aman Gupta, PhD 2012, *Placement: Affiliated Engineering Lab. Edison, NJ, Biomechanical Consultant.*
11) Carson Ingo, PhD 2012, *Placement: Postdoctoral Student, Leiden Medical Center, Leiden, NL.*
12) Benjamin L. Schwartz, PhD 2014, *Placement: Postdoctoral Student, University of Arizona.*
13) Ziying Yin, PhD 2014, *Placement: Postdoctoral Student, Mayo Clinic, Rochester, MN*.
14) Allen Ye, PhD 2015, *Placement: UIC Medical School, MD/PhD student*.
15) Meltum Uyanik, BioE PhD student at UIC, in progress.
16) S. Hassan HosseinNia, Visiting PhD (2012 – 2013) from University of Extremadura, Badajoz, Spain.
17) Viktor Kovacs, Visiting PhD (2013 – 2014) from Budapest Institute of Technology, Budapest, Hungary.
18) Yingjie Liang, Visiting PhD (2014 – 2015) from Hohai University, Nanjing, China.

C. Contributions to Science

1. **MR Technologies for Monitoring Engineered Tissues**. I, with my students and bioengineering collaborators, have for the past ten years been developing new MR based techniques (relaxation, diffusion, elastography) for assessing the growth and development of engineered tissues (osteogenic, chondrogenic and adipose). The rapid advance of tissue engineering and regenerative medicine creates a need for non-invasive, quantitative imaging of tissue constructs both *in vitro* (during incubation and expansion) and *in vivo* (in bioreactors and in animals/humans). This is pioneering research began with our former colleague, Dr. Jeremy Mao (now at Columbia University) and continues at UIC with Professor Anne George and Research Professors Sriram Ravindran and Mrignayani Kotecha. This research was supported by NIH/NIBIB R01 grant EB007537 and by NIH/NIDCR R01 grant DE 11657. This work has been published in a series of papers in Tissue Engineering, Part A, Part B and other bioengineering journals. Items (a – e) below are four recent journal publications in this area and a new book now in its final stages of editing.
   a) M. Kotecha, R.L. Magin, and J. Mao (editors). Magnetic Resonance in Tissue Engineering, John Wiley, NY, NY In Press (2015).
   b) S. Ravindran, M. Kotecha, Z. Yin, A. Ye, CC Huang, R.L. Magin and A. George, "Biological and MRI characterization of biomimetic ECM scaffolds for cartilage tissue regeneration," Biomaterial, In Press (2015).
   c) M. Kotecha, S. Ravindran, T. M. Schmid, A. Vaidyanathan, A. George and R. L. Magin, "Application of sodium triple-quantum coherence NMR spectroscopy for the study of growth dynamics in cartilage tissue engineering," NMR in Biomedicine, vol. 26, pp. 709-717, 2013. PubMed [journal] PMID: 23378198, PMCID: PMC 3634872.
   d) M. Kotecha, D. Klatt, and R.L. Magin, "Monitoring cartilage tissue engineering using magnetic resonance spectroscopy, imaging and elastography," Tissue Engineering, Part B vol. 19, pp. 470-484, 2013. PubMed [journal] PMID: 23574498, PMCID: PMC 3826474.

2. **SLIM/SDP/ULTIMATE MRE**. I have been involved with Co-I Thomas Royston and Dieter Klatt in the development of three patented pulse sequences that greatly reduce the time needed to conduct an MR elastography study (by up to a factor of 3) while at the same time improving the accuracy of the measurement. This technique was extended recently by my PhD student (Ziying Yin) to provide – for the first time – a technique for the simultaneous acquisition of diffusion and elastography data using a single oscillating diffusion and motion encoding gradient. While we first implemented and validated these developments on preclinical MRI systems, they are translatable to clinical systems. This translation is already occurring (see e). As MRE spreads to more clinical applications beyond staging liver fibrosis, we expect that all implementations of it will eventually incorporate our algorithmic improvements, which both reduce imaging time (improving patient comfort and saving money) while at the same time improving accuracy. Articles and patent information on these techniques are provided below.
   a) Klatt D, Yasar TK, Royston TJ, Magin RL. Sample interval modulation for the simultaneous acquisition of displacement vector data in magnetic resonance elastography: theory and application. Physics in medicine and biology. 2013; 58(24):8663-75. NIHMSID: NIHMS545020 PubMed [journal] PMID: 24256743, PMCID: PMC4048719. International Patent Application PCT/US13/71830. Filed: 11/26/2013.
   b) Yin, Z, Magin, RL and Klatt D. Simultaneous MR elastography and diffusion acquisitions: Diffusion-MRE (dMRE)," Magnetic Resonance in Medicine. 2014 71: 1682-1688. PubMed [journal] PMID: 24648402.
   c) Yasar TK, Klatt D, Magin RL, Royston TJ. Selective spectral displacement projection for multifrequency MRE. Physics in medicine and biology. 2013; 58(16):5771-81. NIHMSID: NIHMS513538 PubMed [journal] PMID: 23912182, PMCID: PMC3799856. International Patent Application PCT/US14/15294. Filed: 02/07/2014.
   d) Yasar TK, Liu Y, Klatt D, Magin RL, Royston TJ. Optimal Motion Encoding Scheme for MR Elastography. Proceedings of the International Society for Magnetic Resonance in Medicine (ISMRM) 23rd Annual Meeting and Exhibition (Toronto, CA, May 30 – June 5, 2015). Provisional patent filed on 8/28/2014; UIC OTM Identification number 2015-023 (DI023).

3. **Ultra High field & Wideband MR Elastography**. I, with colleague Richard Magin, and our students have pioneered the implementation of MR elastography (MRE) in ultra high field MRI systems and devised methods, such as use of a geometrically focused wave front, to greatly extend the frequency band over which MRE can be applied. Our application of MRE up to 16 kHz is unprecedented. Wideband (broad frequency range) MRE enables a more accurate and robust multiscale quantification of viscoelastic properties of the material/ specimen/ region of interest being studied that can improve diagnostic ability. This work also enables a more direct comparison between animal models of disease and the clinical condition, accounting for changes in dimensions between, for example, a rodent model and human subject, which necessitates conducting MRE over widely varying frequency ranges. Three publications illustrative of this work are provided.
    a) Liu Y, Yasar TK, Royston TJ. Ultra wideband (0.5-16-kHz) MR elastography for robust shear viscoelasticity model identification. Physics in medicine and biology. 2014; 59(24):7717-7734. PubMed [journal] PMID: 25419651.
    b) Yasar TK, Royston TJ, Magin RL. Wideband MR elastography for viscoelasticity model identification. Magnetic resonance in medicine: official journal of the Society of Magnetic Resonance in Medicine / Society of Magnetic Resonance in Medicine. 2013; 70(2):479-89. NIHMSID: NIHMS403388 PubMed [journal] PMID: 23001852, PMCID: PMC3556381.
    c) Othman SF, Xu H, Royston TJ, Magin RL. Microscopic magnetic resonance elastography (microMRE). Magnetic resonance in medicine: official journal of the Society of Magnetic Resonance in Medicine / Society of Magnetic Resonance in Medicine. 2005; 54(3):605-15. PubMed [journal] PMID: 16088876.

4. **Dynamic tissue viscoelasticity modeling**. Complementary to topic 3 above, I have been involved with Co-investigator, Professor Royston, in developing improved models of soft tissue viscoelasticity based on our ability to measure tissue shear wave behavior over an extended frequency range and to fit these unique data sets using the concepts of fractional calculus. Much of this development can be found in the publications listed under topic 2. Additional publications related to this and which highlight our use of wideband optical elastography, in addition to wideband MR elastography, are provided here.
    a) F.C. Meral, T.J. Royston, R.L. Magin, "Rayleigh-Lamb wave propagation on a fractional order viscoelastic plate," J. of the Acoustical Society of America. 2011 129 (2), 1036 – 1045. PMID: 21361459; PMCID: PMC3063611.
    b) R.L. Magin and T.J. Royston, "Fractional-order elastic models of cartilage: A multi-scale approach," Communications in Nonlinear Science & Numerical Simulation. 2010; 15(3): 657-664.
    c) D. Craiem and R.L. Magin, "Fractional order models of viscoelasticity as an alternative in the analysis of red blood cell (RBC) membrane mechanics," Physical Biology. 2010 vol. 7, pp. 013001-013003. PMID: 20090192; PMCID: PMC3023965.
    d) F.C. Meral, T.J. Royston, and R.L. Magin, " Surface response of a fractional order viscoelastic halfspace to surface and subsurface sources," The Journal of the Acoustical Society of America. 2009; 126(6):3278-85. PubMed [journal] PMID: 20000941, PMCID: PMC2803725.

5. **Fractional Calculus modeling**. During the past ten years of my career I have made key contributions applying fractional calculus modeling in bioengineering. This work has wide potential impact in bioacoustics, tissue engineering, biomaterial development and magnetic resonance imaging. The new imaging and biomarker characterization methods can be directly applied to the characterization of soft tissues such as the white and gray matter of the brain and the muscles and connective tissue of the extremities. My book on this topic, and five recent publications, highlighting the application of the fractional calculus approach to modeling and model identification are listed below.
    a) R.L. Magin, Fractional Calculus in Bioengineering, Begell House, CT, (2006).
    b) C. Ingo, R.L. Magin, L. Colon-Perez, W. Triplett, and T.H. Mareci, "On random walks and entropy in diffusion weighted magnetic resonance imaging studies of neural tissue," Magnetic Resonance in Medicine, vol. 71, pp. 617-627, 2014. PubMed [journal] PMID: 24648402.
    c) R. L. Magin, C. Ingo, L. Colon-Perez, W. Triplett, and T.H. Mareci, "Characterization of anomalous diffusion in porous biological tissues using fractional order derivatives and entropy," Microporous and Mesoporous Materials, vol. 178, pp. 39-43, 2013. PMID: 24072979 [PubMed] PMCID: PMC3780456.
    d) D.A. Reiter, R.L. Magin, W. Li., J.J. Trujillo, M. Pilar Velasco, and R.G. Spencer, "Anomalous T2 relaxation in normal and degraded cartilage," Magnetic Resonance in Medicine, (in press).

D. Research Support (in last 3 years).

Ongoing Research Support

NSF NHMFL Grant ML-Magin-002 Magin (PI) 05/01/14 – 02/28/17
Entropy as a Measure of Non-Gaussian Diffusion in Fixed Rat Brain Tissues
This grant provides imaging time (100 hours per year) using the 17.6 T imaging spectrometer in Gainesville, FL at the Advanced Magnetic Resonance Imaging and Spectroscopy facility of the National High Magnetic Field
Role: PI

Visiting Fellowship Award, China Magin (PI) 03/01/15 – 02/28/18
Anomalous Diffusion in MRI: Fractional-Order Modeling of Partial Differential Equations
The primary objective of this work is to develop new techniques for measuring diffusion in complex, heterogeneous materials, such as biological tissues. The fellowship will support three visits to Hohai University in Nanjing, China.
Role: PI

Completed Research Support in past 3 years

R01 EB007537 Magin (PI) 05/01/09 - 02/28/14
MR Technologies for Monitoring Engineered Tissues
The objective of this study is to develop new techniques for monitoring engineered chondrogenic tissues using magnetic resonance imaging and magnetic resonance elastography. Magnetic resonance imaging provides three dimensional views of developing tissue at all stages of growth without the need to sacrifice the animal or to biopsy the tissue. Magnetic resonance elastography gives a direct measure of the strength and stiffness of regenerating tissue: critical information needed to guide the design of new methods of tissue engineering and to assess the success of tissue implants for restoring tissue damaged by disease, injury or cancer treatment.
Role: Co-Investigator

NSF 0821313 Magin (PI) 09/01/09 - 08/31/14
MRI: Acquisition of a High Field Magnetic Resonance Imaging System for Science and Engineering Research
This is a major research instrumentation grant solely for the purpose of purchasing the named equipment.
Role: Co-Investigator