Lorenzo SALA, PhD

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Employment

- **Post doc** at Inria Saclay, Ile-de-France. 2020 - now.
  Mentor: I. Vignon-Clementel. *Project:* modelling of hemodynamics in the entire circulation for targeted surgical interventions in the liver.
- Collaboration as **consultant for Gspace LLC**. 2020-2021.
  Gspace LLC is a consulting company in computational modeling for smart solutions in engineering and life sciences.
  Project: modelling the structural reaction of mattress to body weight.
- **Research Associate** at Imperial College London. 2019 - 2020.
  Mentor: P. Degond. *Project:* modelling sperm-mucus interactions across scales to better mechanism involved in the mammalian reproduction.
- **Engineer researcher** at the Université de Strasbourg. May - September 2016.
  Mentors: G. Guidoboni, C. Prud'homme. *Project:* Eye2Brain: study and implement innovative mathematical and physiological models to investigate the connection between the eye and the brain.

Qualifications

- **Qualified for the functions of "Maître de conférences"**. February, 2020.
- **PhD in Applied Mathematics** at the Université de Strasbourg. 2016 - 2019.
  Title: Mathematical modelling and simulation of ocular blood flows and their interactions.
  Advisors: C. Prud'Homme, G. Guidoboni, M. Szopos.
- **MSc in Computational Science and Engineering** at Politecnico di Milano. 2013 - 2016.
  Master thesis: A Cellular Scale Model of Aqueous Humour Production.
  Advisors: R. Sacco, A.G. Mauri, G. Guidoboni.
- **BSc in Mathematical Engineering** at Politecnico di Milano. 2010 - 2013.

Patents

- **Model-Based Sensor Technology for Detection of Cardiovascular Status**.
  Inventor: G. Guidoboni *Authors:* G. Guidoboni, L. Sala
  PCT Patent Application No.: PCT/US2019/052738. Filed on 24/09/2019

Funding

- 2021 AIM Square (1 week every year for 3 years) entitled *Mathematical modeling of the relationship between cardiovascular function and ballistocardiogram.* American Institute of Mathematics, San José (CA), USA. 2022-2024.
  https://aimath.org/programs/squares/
- Young researchers scholarship for the **9e Biennale Française des Mathématiques Appliquées et Industrielles**.
  Fees and accommodation grant. 2019.
- Contribution to the grant **Mathematical Modelling, Simulation and Optimization for Societal Challenges with Scientific Computing: Eye2Brain project**. European Union's Horizon 2020 research and innovation programme. Grant agreement No 731063. C. Prud'homme. 2016-2018.
- Contribution to the grant **Prix Espoir IdEx** (*Initiative d'excellence*). M. Szopos. 2018.
- **PhD scholarship** administrated by the Doctoral School *Mathematics, Engineering and Computer Science* of the University of Strasbourg. 2016-2019.

Honours and awards

- **VPHi-InSilicoTrials PhD Thesis Award in In Silico Medicine for potential appliction in industrial R&D**
  VPH2020 Conference. August 28, 2020, Paris, France.
  shorturl.at/ixOSY; shorturl.at/uCFW9.
- **Best PhD Thesis Award - Prize of the Research Commission of the University of Strasbourg**.
  June 26, 2020, Strasbourg, France.
  shorturl.at/aeCFO; shorturl.at/fkEG6
- **Oral presentation at 2018 and 2019 Annual Meeting of the Association for Research in Vision and Ophthalmology (ARVO).** Selected among circa 1000 applicants.
  2018, Vancouver, Canada: *A web-based interface for ocular hemodynamics and biomechanics analysis via the Ocular Mathematical Virtual Simulator*.
  2019, Honolulu (HI), USA: *Analysis of IOP and CSF alterations on ocular biomechanics and lamina cribrosa hemodynamics*.
- **Best Poster Award** - University of Strasbourg Doctorate School in Mathematics, Engineering and Computer Science. October 2, 2017, Strasbourg, France.

Responsibilities

- Review for *Applied Mathematics, Modeling and Computational Science*, *International Journal for Numerical Methods in Biomedical Engineering* and *Computers in Biology and Medicine*.
- Creator and maintainer of the SIMBIOTX team website https://team.inria.fr/simbiotx/. 2020-2022.

Invited talks

- **Sensitivity analysis of a partial hepatectomy hemodynamics model.**
  15th World Congress on Computational Mechanics, Minisymposium Efficiency and reliability in biomedical modeling: computational and mathematical advances Yokohama, Japan. 01-05/08/2022.
- **Numerical implementation and preliminary results of a swimmer-obstacle-fluid interactions model.**
  14th World Congress on Computational Mechanics: Multidisciplinary Alliance in Biosciences: Modeling, Computing, Technology and Clinical Applications. (Online) Paris, France. 13/01/2021.
- **Sperm motility pattern formation study via a swimmer-obstacle interactions model**.
  2021 Virtual Joint Mathematics Meetings: SIAM Minisymposium on Complex Fluids in Living Systems. Online. 08/01/2021.
- **Mathematical modelling and simulation of ocular blood flows**.
  VPH2020 Conference. (Online) Paris, France. 28/08/2020.
- **The Ocular Mathematical Virtual Simulator: modelisation and simulation.**
  Applied PDEs Seminar. Imperial College London, UK. 29/11/2019.
- **From medicine to mathematics and back: an application in ophthalmology**.
  European Numerical Mathematics and Advanced Applications Conference 2019. Egmond aan Zee, The Netherlands. 30/09/2019.
- **The Ocular Mathematical Virtual Simulator: towards uncertainty quantification**.
  6th International Conference on Computational and Mathematical Biomedical Engineering. Sendai, Japan. 11/06/2019.
- **An operator splitting method for the time discretization of a multi-scale model in ophthalmology**.
  9e Biennale Française des Mathématiques Appliquées et Industrielles. Guidel Plages (Morbihan), France. 14/05/2019.
- **Mathematical modelling and simulation of ocular blood flow and their interactions**.
  Workshop Modeling the eye as a window on the body. American Institute of Mathematics, San José (CA), USA. 17/10/2018.
- **OMVS: A Hemodynamical and Biomechanical Study towards Clinical Applications.**
  13th World Congress on Computational Mechanics: Multidisciplinary Alliance in Biosciences: Modeling, Computing, Technology and Clinical Applications. New York (NY), USA. 24/07/2018.
- **HDG Method and Toolbox in Feel++** and **Multiphysic modeling of the Eye using Feel++**.
  Workshop 5th Feel++ User Days. IRMA, Strasbourg, France. 14/09/2017.
- **Hi-POD reduction techniques for parametrized fluid dynamics problems**.
  Séminaire Equations aux dérivées partielles. IRMA, Strasbourg, France. 11/10/2016.

Oral presentations

- **Sensitivity analysis of a cardiovascular mathematical model targeting surgical actions in the liver.**
  GDR Mecabio Santé 2022: Macroscale and multiscale biomechanics for Health. Sorbonne Université, Paris, France. 01/12/2022.
- **Sensitivity analysis on the modeling parameters of a cardiovascular model simulating partial hepatectomy.**
  VPH2022 Conference Virtual Physiological Human: Computational modeling in health and disease. Porto, Portugal. 07/09/2022.
- **Cardiovascular model simulating partial hepatectomy: uncertainty quantification and sensitivity analysis study.**
  9th World Congress of Biomechanics: Inverse Problems and Data Assimilation in the Circulatory System. (Online) Taipei, Taiwan. 10/07/2022.
- **The Ocular Mathematical Virtual Simulator: a sensitivity analysis study**.
  Congrès d'Analyse Numérique pour les Jeunes. Online. 03/12/2020.
- **Monitoring cardiovascular health via ballistocardiography: a virtual predictive study on arterial stiffening**.
  Clinical: monitoring & connected health. VPH2020 Conference. (Online) Paris, France. 26/08/2020.
- Poster **Unconditionally stable operator splitting method for a multiscale application in ophthalmology.**
  44e Congrès National d'Analyse Numérique. Centre Azureva, Cap d'Agde, France. 30/05/2018.
- **Demo tissue perfusion in the eye**
  Workshop Mathematical Modelling, Simulation and Optimization for Societal Challenges with Scientific Computing (MSO4SC). Budapest, Hungary. 23/05/2017. https://www.youtube.com/watch?v=F4JIgA1PCcA&t=1s
- Poster **Patient-specific virtual simulator of tissue perfusion in the lamina cribrosa**.
  2017 Annual Meeting of the Association for Research in Vision and Ophthalmology. Poster session "Imaging: Macula Retina, Blood Flow, OCT Angiography". Baltimore(MD), USA. 07/05/2017.
- Poster **Hi-POD reduction techniques for parametrized fluid dynamics problems**.
  Numerical methods for PDEs: recent developments in numerical methods for model reduction. IHP, Paris, France. 08/11/2016.

Organization scientific events

- Weekly meeting of the SIMBIOTX team. 01/10/2020 - 31/12/2022.
- Minisymposium **Advances in the Multiscale and Multiphysics Modeling of Biological Fluids: Theoretical and Numerical Aspects**. *SIAM Conference on Computational Science and Engineering (CSE23).*
  Amsterdam, The Netherlands. 26/02/2023 - 03/03/2023.
- Special session **Digital twin of different scales and biological processes: the example of liver**.
  18th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering (CMBBE2023).
  Paris, France. 03 - 05/05/2023.

Teaching and supervision

- **Presentation to junior high school students** for their *stage d'observation de troisiéme.* INRIA Saclay. 17/02/2022.
- Mini-class **Mathematics and Medicine** for 2nd year medical students of the *Double cursus médecine / science* of *École de l'Inserm Liliane Bettencourt.* Online - virtual format. Afternoon 09/02/2021.

- Undergraduate course **Mathématique I**. *Review of the fundamentals of mathematics for 1st year undergraduate students in Biology.* Université de Strasbourg, 64h in 2017-2018 and 32h in 2018-2019.
- Undergraduate course **Algorithme et Programmation en C++**. *Practical (Computed-based) lessons on algorithms and coding in C++ for 3rd year undergraduate students in Mathematics.* Université de Strasbourg, 32h in 2018-2019.
- **Supervision**:
  - J. Kowalski. Master 2 internship. *Whole body vascular transport model and applications to human liver diseases.* INRIA Saclay, 2022.
  - L. Thiebaud. Master 2 internship. *Mathematical modeling of the human liver hemodynamics.* INRIA Saclay. 2021.
  - T. Saigre. Master 2 internship and PhD in progress. *Mathematical modeling, simulation and reduced order modeling of ocular blood flows and their interactions: Building the Eye's Digital Twin.* Université de Strasbourg. 2021.
  - A. Walczak. Final Master Project. *Models of Swarmalator Pursuit and Self-Organisation.* Imperial College London. 2020.
  - G. Kim-J. Liu-Z. Sun-B. Xiao. Year 2 Group Project. *Self-propelled particles moving through obstacles: analytical and numerical study.* Imperial College London. 2020.
  - N. Marazzi. Master 2 internship. *Influence of low perfusion pressure on the diastolic hemodynamics in central retinal vessels: a data-driven computational study.* University of Missouri. 2019.

Publications

Peer-reviewed articles

13. **A HDG method for elliptic problems with integral boundary condition: Theory and Applications.**
    S. Bertoluzza, G. Guidoboni, R. Hild, D. Prada, C. Prud'homme, R. Sacco, <u>L. Sala</u> *, M. Szopos.
    Submitted. *corresponding author

12. **How environment affects active particle swarms: a case study.**
    P. Degond, A. Manhart, S. Merino-Aceituno, D. Peurichard, <u>L. Sala</u> .
    Royal Society Open Science, 9 (12). 2022.

11. **Sensitivity Analysis of a Mathematical Model Simulating the Post-Hepatectomy Hemodynamics Response.**
    <u>L. Sala</u> , N. Golse, A. Joosten, E. Vibert, I. Vignon-Clementel.
    Annals of Biomedical Engineering, 1-20. 2022.

10. **Mechanism-driven modeling to aid noninvasive monitoring of cardiac function via ballistocardiography.**
    M. Zaid, <u>L. Sala</u> et al.
    Frontiers in Medical Technology, 4 (2673-3129). 2022.

9. **Combining physiology-based modeling and evolutionary algorithms for personalized, non-invasive cardiovascular assessment based on electrocardiography and ballistocardiography**
   N.M. Marazzi, G. Guidoboni, M. Zaid, <u>L. Sala</u> et al.
   Frontiers of Physiology, 12 (1664-042X). 2021.

8. **Uncertainty propagation and sensitivity analysis: results from the Ocular Mathematical Virtual Simulator.**
   <u>L. Sala</u> , C. Prud'homme, M. Szopos.
   Mathematical Biosciences and Engineering, 8 (3), pp.2010-2032. 2021.

7. **Neurodegenerative disorders of the eye and of the brain: a perspective on their fluid-dynamical connections and the potential of mechanism-driven modeling.**
   G. Guidoboni, R. Sacco, M. Szopos, <u>L. Sala</u> , A.C.V. Vercellin, B.A. Siesky, A. Harris
   Frontiers in Neuroscience, 14. 2020.

6. **Using sensor signals in the early detection of heart failure: A case study.**
   L.A. Despins, G. Guidoboni, M. Skubic, <u>L. Sala</u> , M. Enayati, M. Popescu, C.B. Deroche.
   Journal of Gerontological Nursing, 46(7), pp.41-46. 2020.

5. **A Theoretical Study of Aqueous Humor Secretion Based on a Continuum Model Coupling Electrochemical and Fluid-Dynamical Transmembrane Mechanisms.**
   <u>L. Sala</u> , A.G. Mauri, R. Sacco, D. Messenio, G. Guidoboni, A. Harris.
   Communications in Applied Mathematics and Computational Science, 14(1), pp.65-103. 2019.

4. **Cardiovascular function and ballistocardiogram: a relationship interpreted via mathematical modeling**.
   G. Guidoboni, <u>L. Sala</u> , M. Enayati, R. Sacco, M. Szopos, J.M. Keller, M. Popescu, L. Despins, V. Huxley, M. Skubic.
   IEEE Transactions on Biomedical Engineering. 2019

3. **Ocular mathematical virtual simulator: A hemodynamical and biomechanical study towards clinical applications**.
   <u>L. Sala</u> , C. Prud'homme, G. Guidoboni, M. Szopos.
   Journal of Coupled Systems and Multiscale Dynamics, 6(3), pp.241-247. 2018

2. **Multiscale nature of ocular physiology**.
   <u>L. Sala</u> , R. Sacco, G. Guidoboni.
   Journal for Modeling in Ophthalmology, 2(1), pp.12-18. 2018.

1. **Electro-fluid dynamics of aqueous humor production: simulations and new directions**.
   A.G. Mauri, L. Sala , P. Airoldi, G. Novielli, R. Sacco, S. Cassani, G. Guidoboni, B.A. Siesky, A. Harris.
   Journal for Modeling in Ophthalmology, 1(2), pp.48-58. 2016.

Peer-reviewed book chapters

1. **Mathematical modeling of the cerebrospinal fluid flow and its interactions.**
   L. Sala , F. Salerni, M. Szopos.
   Chapter in the book Mathematical Modeling of Ocular Fluid Dynamics: From Theory to Clinical Applications.
   Editors: G. Guidoboni, A. Harris, R. Sacco.
   Springer-Birkhauser (New York). *Book series:* Modeling and Simulation in Science, Engineering, and Technology *Release date:* November, 2019.

Peer-reviewed conference proceedings

13. **Mathematical assessment of the role of three factors entangled in the development of glaucoma by means of the Ocular Mathematical Virtual Simulator.**
    L. Sala , C. Prud'homme, G. Guidoboni, M. Szopos, A. Harris.
    In: Vermolen F.J., Vuik C. (eds) Numerical Mathematics and Advanced Applications ENUMATH 2019 Lecture Notes in Computational Science and Engineering, vol 139, pp 851-860. Springer, Cham. 2021

12. **Influence of low perfusion pressure on the diastolic hemodynamics in central retinal vessels: a data-driven computational study.**
    N. Marazzi, L. Sala , R.C. Shujuan, C.-Y. Cheng, A. Harris, G. Guidoboni.
    Investigative Ophthalmology & Visual Science, 61(7), pp.614-614. 2020.

11. **Case study exemplar of detecting severe diastolic dysfunction using ballistocardiogram.**
    L.A. Despins, G. Guidoboni, M. Skubic, L. Sala , M. Enayati, J. Keller, M. Popescu.
    Innovation in Aging, 3(Supplement_1), pp.S88-S89. 2019.

10. **An operator splitting method for the time discretization of a multi-scale model in ophthalmology.**
    L. Sala , C. Prud'homme, G. Guidoboni, M. Szopos.
    In 9e Biennale Française des Mathématiques Appliquées et Industrielles (SMAI). 2019.

9. **A web-based interface for ocular hemodynamics and biomechanics analysis via the Ocular Mathematical Virtual Simulator.**
   L. Sala , G. Guidoboni, C. Prud'homme, M. Szopos, A. C. V. Vercellin, B. A. Siesky, A. Harris.
   Investigative Ophthalmology & Visual Science, 60(9), pp. 4277-4277. 2019.

8. **Towards a full model for ocular biomechanics, fluid dynamics, and hemodynamics**.
   L. Sala , C. Prud'homme, G. Guidoboni, M. Szopos.
   Journal for Modeling in Ophthalmology, 2(2), pp.7-13. 2018.

7. **Analysis of IOP and CSF alterations on ocular biomechanics and lamina cribrosa hemodynamics**.
   L. Sala , C. Prud'homme, G. Guidoboni, M. Szopos, B.A. Siesky, A. Harris.
   Investigative Ophthalmology & Visual Science, 59(9), pp.4475-4475. 2018.

6. **A theoretical study of the role of conformational properties of transepithelial ion pumps on aqueous humor production**.
   R. Sacco, L. Sala , A.G. Mauri, D. Messenio, G. Guidoboni, B.A. Siesky, A. Harris
   Investigative Ophthalmology & Visual Science, 59 (9), 1656-1656. 2018.

5. **A theoretical study of the role of conformational properties of transepithelial ion pumps on aqueous humor production**.
   R. Sacco, A.G. Mauri, L. Sala , S. Cassani, B.A. Siesky, G. Guidoboni, A. Harris.
   Investigative Ophthalmology & Visual Science, 59(9), pp.1656-1656. 2018.

4. **Unconditionally stable operator splitting method for a multiscale application in ophthalmology**.
   G. Guidoboni, C. Prud'homme, L. Sala , M. Szopos.
   In 44e Congrès National d'Analyse Numérique. May, 2018.

3. **Patient-specific virtual simulator of tissue perfusion in the lamina cribrosa**.
   L. Sala , C. Prud'Homme, D. Prada, F. Salerni, C. Trophime, V. Chabannes, M. Szopos, R. Repetto, S. Bertoluzza, R. Sacco, A. Harris.
   Investigative Ophthalmology & Visual Science, 58(8), pp. 727. 2017.

2. **Hi-POD solution of parametrized fluid dynamics problems: preliminary results**.
   D. Baroli, C.M. Cova, S. Perotto, L. Sala , A. Veneziani.
   In: Benner P., Ohlberger M., Patera A., Rozza G., Urban K. (eds) Model Reduction of Parametrized Systems. MS&A (Modeling, Simulation and Applications), vol 17, pp 235-254. Springer, Cham. 2017.

1. **The role of HCO$_3^-$ and NA/K ATPase in the regulation of aqueous humor production: a mathematical model.**
   R. Sacco, A.G. Mauri, <u>L. Sala</u> , S. Cassani, B.A. Siesky, G. Guidoboni, A. Harris.
   Investigative Ophthalmology & Visual Science, 57(12). 2016.