

## Loris Fichera, Ph.D.

Assistant Professor

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Robotics Engineering Program – Department of Computer Science

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### Research Interests

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My research interests are primarily in computer/robot assisted surgery and, more generally, in the use of engineering and computer science to enhance medical diagnosis and treatment. I seek to enhance medical procedures and enable new ones that are not possible with current instrumentation.

### Education

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**Ph.D. 2015 Medical Robotics, University of Genoa / Italian Institute of Technology, Italy**

Dissertation: Cognitive Supervision for Robot-Assisted Minimally Invasive Laser Surgery

Advisors: Darwin G. Caldwell, Leonardo S. Mattos, Diego Pardo

Evaluation: Excellent – **nominated as an outstanding PhD Thesis by the University of Genoa, published in the Springer “Ph.D. Theses” series**

**M.S. 2011 Computer Engineering, University of Catania, Italy**

Dissertation: Design and Implementation of a Monitoring System for Photovoltaic Power Stations

Advisor: Corrado Santoro

Evaluation: Full marks, *cum laude*

**B.S. 2008 Computer Engineering, University of Catania, Italy**

Final Project: Design and Implementation of a Localization System for Autonomous Mobile Robots

Advisor: Corrado Santoro

Evaluation: Full marks, *cum laude*

### Prior Research Experience

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**Nov 2015- Postdoctoral Research, Dept. of Mechanical Engineering, Vanderbilt University, USA**

**Aug 2017** Research focuses on image-guided ear surgery:

**Enable minimally-invasive endoscopy of the middle ear.** I created a novel continuum robotic endoscope (diameter < 2 mm) to see into the middle ear passing through the nose and the natural orifice of the Eustachian Tube; the device features tip articulation (previously unavailable in endoscopes of this size) and a chip-tip camera with fiber optic light sources. The endoscope has been validated in-vitro and is now being evaluated in cadaver studies.

**Clinical translation of minimally-invasive cochlear implantation.** Cochlear implants are electronic devices that can restore hearing to deaf individuals. Researchers at Vanderbilt have developed a minimally-invasive approach to cochlear implantation, but it requires drilling near sensitive nerves embedded in the skull. Working side-to-side with doctors at Vanderbilt University Medical Center, I developed a drilling protocol to reduce the risk of thermal injury to these nerves. The protocol has been validated in cadaver studies and will be adopted in clinical trials starting January 2017.

**Clinical validation of robotic bone milling.** This research leverages medical image guidance to enable robotic bone milling during ear surgery. This is a challenging procedure because it involves operating in proximity of vital anatomical structures embedded in the skull, including several sensitive nerves and the carotid artery. Working with a graduate student, I developed and demonstrated a method to automatically reduce drilling forces when milling close to vital anatomy, thus enhancing the safety of this procedure. This method has been validated in-vitro and is now being tested in cadaver studies.

Jan 2012 - **Doctoral Research, Dept. of Advanced Robotics, Italian Institute of Technology, Italy**  
Oct 2015

The aim of this research was to lay the groundwork for the automatic supervision of laser incisions during robot-assisted laser microsurgery of soft tissue. The intent of this technology is to monitor laser-induced effects that are difficult or impossible to perceive by unaided human senses, thereby enhancing the surgeon's control on laser incisions. This work was conducted in the scope of a EU-funded project (uRALP, seventh framework programme, 2012-2015).

Demonstrated the feasibility of the online estimation of the laser cutting depth and the temperature of tissue during laser ablation.

Estimated laser energy effects on tissue based on mathematical models; these models are extracted from experimental data by means of machine learning techniques.

Demonstrated the feasibility of the automatic control of the laser cutting depth using the above mentioned models.

Developed laser-tissue interaction experiments using a surgical CO2 laser.

Jan 2009 – **MS Research, Dept. of Mathematics and Computer Science, Univ. of Catania, Italy**  
Jul 2011

During my Master's program, I was a member of the Autonomous and Robotic Systems Lab, where I conducted research in intelligent agents and robotics.

Developed a methodology to extend object-oriented programming languages with declarative constructs.

Demonstrated the applicability of this methodology to create a Belief-Desire-Intention (BDI) reasoning engine to define the behavior of autonomous agents and robots.

Apr - Jul **Visiting Research Fellow, School of Engineering and Tech., Univ. of Hertfordshire, UK**  
2010

As part of a collaborative project with the Univ. of Catania, I realized an exocentric

vision software framework for the teleoperation of mobile robots, based on OpenGL.

## Grants and Funding

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1. **NIH R21** “Transnasal Diagnosis of Middle Ear Disease,” R.J. Webster III (PI), Jack H. Noble, Paul T. Russell III, R.F. Labadie. For \$446,413 over two years (9/1/2017 – 8/31/2019). **Note: I led the development of this proposal during my postdoc at Vanderbilt, and wrote many sections of it personally. WPI will receive a sub-award (currently in preparation).**
2. **WPI Engineering Seed Grant** “Make the laser feel more like a scalpel: combining haptics and digital holography to enhance the perception of laser cutting depth during surgery,” L. Fichera (PI), Cosme Furlong. For \$17,000 in direct costs over one year (2018)
3. **WPI Engineering Seed Grant** “Intraoperative detection of cancerous tissue for laser-based microsurgery using tissue-specific dynamic thermal response signature,” L. Fichera (PI), Andrea Arnold. For \$13,000 in direct costs over one year (2018)
4. **IIT PhD Fellowship** For €49,500 over three years (01/2012 – 12/2014)  
I was the recipient of an Italian Institute of Technology (IIT) fellowship providing financial support during my doctoral studies. My application ranked 1<sup>st</sup> out of 30+ (the call was advertised through the “Robotics Worldwide” mailing list and was open to international students).
5. **Erasmus Placement Mobility Grant** For €2,600 over four months (04/2010 – 07/2010)  
This European Commission Grant supported my research internship at the University of Hertfordshire.

## Honors and Awards

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- 2017 **Best Engineering Poster Award, Vanderbilt Postdoctoral Symposium**
- 2016 **Koh Young Investigator Scholarship, International Society for Computer Assisted Surgery**  
I was awarded a scholarship by the International Society for Computer Assisted Surgery (ISCAS) for my paper *Thermal monitoring of the facial recess during drilling for minimally invasive cochlear implantation: comparison of manual and automated approaches*. The scholarship supported by attendance and presentation at the 20<sup>th</sup> ISCAS meeting in Heidelberg, Germany.
- 2015 **Best Paper Finalist, International Conference on Robotics and Automation**
- 2015 **Best Student Paper Finalist, International Conference on Robotics and Automation**
- 2015 **Best Medical Robotics Paper Finalist, International Conference on Robotics and Automation**  
My paper *Feed Forward Incision Control for Laser Microsurgery of Soft Tissue* was selected as a finalist for the above awards at the International Conference on Robotics and Automation (ICRA) in Seattle, United States.

**2015 Outstanding PhD Thesis, University of Genoa, Italy**

My dissertation *Cognitive Supervision for Robot-Assisted Minimally Invasive Laser Surgery* was nominated as an outstanding PhD thesis by the faculty of Italian Institute of Technology / University of Genoa, and published in the Springer PhD Theses series

**2011-2009 Runner-up, Eurobot Open Competition (2 times)**

Eurobot Open is an international student robotics competition where autonomous robots compete to accomplish different tasks (manipulation, sorting, etc.). I was part of the team of the University of Catania, Italy, from 2008 to 2011 and was responsible for the reasoning engine of the robot and the development of game strategies.

## Publications

**Manuscripts in preparation**

1. Z. Li, S. Kadam, **L. Fichera**, Design Optimization of Continuum Notched-Tube Wrists Using Anatomical Information. Expected submission: March 2018.

**Journal Articles**

2. K. Kesler, N.P. Dillon, **L. Fichera**, R.F. Labadie, Human Kinematics of Cochlear Implant Surgery: An Investigation of Insertion Micro-Motions and Speed Limitations, *Otolaryngology – Head and Neck Surgery* 57(3):493-498, 2017.
3. M.A. Siebold, N.P. Dillon, **L. Fichera**, R.F. Labadie, R.J. Webster III, J.M. Fitzpatrick, Safety Margins in Robotic Bone Milling: From Registration Uncertainty to Statistically Safe Surgeries, *International Journal of Medical Robotics and Computer Assisted Surgery* 13(3), 2017.
4. N.P. Dillon, **L. Fichera**, K. Kesler, M. Zuniga Manrique, J.E. Mitchell, R.F. Labadie, A protocol for reduced heat generation during guided manual drilling for minimally invasive cochlear implantation surgery, *Annals of Biomedical Engineering* 45(9):1-12, 2017.
5. P. Illiano, C.E. Bass, **L. Fichera**, L. Mus, E.A. Budygin, D. Leo, S. Espinoza, R.R. Gainetdinov, Recombinant Adeno-Associated Virus-mediated rescue of function in an animal model of Dopamine Transporter Deficiency Syndrome, *Scientific Reports* 7, 2017.
6. **L. Fichera**, F. Messina, C. Santoro, G. Pappalardo, A Python Framework for Programming Autonomous Robots using a Declarative Approach, *Science of Computer Programming* 139:35-55, 2017.
7. A. Acemoglu, **L. Fichera**, I.E. Kepiro, D.G. Caldwell, L.S. Mattos, Laser Incision Depth Control in Robot-Assisted Soft Tissue Microsurgery, *Journal of Medical Robotics Research* 2(3):174006, 2017.
8. **L. Fichera**, N.P. Dillon, D. Zhang, I. Godage, M.A. Siebold, B.I. Hartley, J.H. Noble, P.T. Russell III, R.F. Labadie, R.J. Webster III, Through the Eustachian Tube and Beyond: A New Miniature Robotic Endoscope to See into the Middle Ear, *Robotics and Automation Letters* 2(3):1488-1494, 2017.
9. **L. Fichera**, D. Pardo, P. Illiano, J. Ortiz, D.G. Caldwell, and L.S. Mattos, Online Estimation of Laser Incision Depth for Transoral Microsurgery: Approach and Preliminary Evaluation, *International*

*Journal of Medical Robotics and Computer Assisted Surgery* 12(1):53-61, 2016.

10. D. Pardo, **L. Fichera**, D. Caldwell, and L.S. Mattos, Learning Temperature Dynamics on Agar-based Phantom Tissue Surface during Single Point CO<sub>2</sub> Laser Exposure, *Neural Processing Letters* 42(1):55-70, 2015.

#### Refereed Conference Papers

1. **L. Fichera**, N.P. Dillon, D. Zhang, I. Godage, M.A. Siebold, B.I. Hartley, J.H. Noble, P.T. Russell III, R.F. Labadie, R.J. Webster III, Through the Eustachian Tube and Beyond: A New Miniature Robotic Endoscope to See into the Middle Ear, in *IEEE International Conference on Robotics and Automation*, Singapore, 2017. [appeared on the Robotics and Automation Letters]
2. S. Lin, **L. Fichera**, M.J. Fulton, R.J. Webster III. Don't Get Burned: Thermal Monitoring of Vessel Sealing using a Miniature Infrared Camera. *SPIE Medical Imaging*, Orlando, Florida, 2017.
3. N.P. Dillon, **L. Fichera**, P.S. Wellborn, R.F. Labadie, R.J. Webster III, Making Robots Mill Bone More Like Human Surgeons: Using Bone Density and Anatomic Information to Mill Safely and Efficiently, in *IEEE International Conference on Intelligent Robots and Systems*, Daejeon, Korea, 2016.
4. **L. Fichera**, N.P. Dillon, K. Kesler, M. Zuniga Manrique, J.E. Mitchell, R.F. Labadie, Thermal monitoring of the facial recess during drilling for minimally invasive cochlear implantation: comparison of manual and automated approaches, in *Proceedings of the 30<sup>th</sup> International Congress and Exhibition on Computer Assisted Radiology and Surgery (CARS)*, Heidelberg, Germany, 2016. **Recipient of the ISCAS Young Investigator Scholarship.**
5. **L. Fichera**, C. Pacchierotti, E. Olivieri, D. Prattichizzo, and L. S. Mattos, Kinesthetic and Vibrotactile Haptic Feedback Improves the Performance of Laser Microsurgery, in *IEEE Haptics Symposium*, Philadelphia, USA, 2016.
6. **L. Fichera**, I.E. Kepiro, D.G. Caldwell, L.S. Mattos, Towards Automatic Laser Incision of Soft Tissue for Transoral Microsurgery, in *5th Joint Workshop on New Technologies for Computer/Robot Assisted Surgery (CRAS)*, Brussels, Belgium, 2015.
7. **L. Fichera**, D. Pardo, P. Illiano, D.G. Caldwell, and L.S. Mattos, Feed Forward Incision Control for Laser Microsurgery of Soft Tissue, in *IEEE International Conference on Robotics and Automation*, Seattle, USA, 2015. **Best Paper Finalist. Best Student Paper Finalist. Best Medical Robotics Paper Finalist.**
8. **L. Fichera**, D. Pardo, P. Illiano, D.G. Caldwell, and L.S. Mattos, New Assistive Technologies for Laser Microsurgery, in *4th Joint Workshop on New Technologies for Computer/Robot Assisted Surgery (CRAS)*, Genova, Italy, 2014.
9. D. Pardo, **L. Fichera**, D.G. Caldwell, and L. S. Mattos, Thermal Supervision during Robotic Laser Microsurgery, in *5th IEEE RAS & EMBS International Conference on Biomedical Robotics and Biomechatronics*, Sao Paulo, Brazil, 2014.
10. **L. Fichera**, D. Pardo, and L.S. Mattos, Artificial Cognitive Supervision during Robot-Assisted Laser Surgery, in *3rd Joint Workshop on New Technologies for Computer/Robot Assisted Surgery (CRAS)*, Verona, Italy, 2013.

11. **L. Fichera**, D. Pardo, and L.S. Mattos, Supervisory System for Laser-Assisted Phonomicrosurgery, in *Engineering in Medicine and Biology Society (EMBC), 2013 Annual International Conference of the IEEE*, Osaka, Japan, 2013.
12. **L. Fichera**, D. Pardo, and L.S. Mattos, Modeling Tissue Temperature Dynamics during Laser Exposure, in *International Work Conference on Artificial Neural Networks (IWANN)*, Tenerife, Spain, 2013.
13. **L. Fichera**, D. Marletta, C. Santoro, and V. Nicosia, Flexible Robot Strategy Design Using Belief-Desire-Intention Model, in *Research and Education in Robotics - Eurobot 2010*, D. Obdržálek and A. Gottscheber, Eds., ser. Communications in Computer and Information Science, vol. 156, Springer, 2011, pp.57–71.

#### **Non-refereed/Abstract/Workshop Papers**

1. M.G. Zuniga, K. Kesler, N.P. Dillon, **L. Fichera**, J.E. Mitchell, R.F. Labadie, Heat generated during temporal bone drilling: is the facial nerve at risk?, in *Combined Otolaryngology Spring Meetings, San Diego, CA, 2017*.
2. K. Kesler, N.P. Dillon, **L. Fichera**, R.F. Labadie, Human Kinematics of Cochlear Implant Insertion at Various Speeds, in *American Academy of Otolaryngology–Head and Neck Surgery, Annual Meeting & OTO EXPOSM*, San Diego, CA, 2016.
3. **L. Fichera**, D. Pardo, and L. S. Mattos, Thermal Supervision during Robotic Laser Microsurgery, in *Workshop on Robotic Microsurgery and Image-Guided Surgical Interventions*, 5th IEEE RAS & EMBS International Conference on Biomedical Robotics and Biomechatronics, Sao Paulo, Brazil, 2014.
4. **L. Fichera**, D. Pardo, N. Deshpande, and L. S. Mattos, On-line Estimation of Ablation Depth During CO<sub>2</sub> Laser Exposure, in *Workshop on Cognitive Surgical Robotics*, IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2013). Tokyo, Japan, 2013.
5. **L. Fichera**, D. Pardo, and L. S. Mattos, Virtual Supervision for a Virtual Scalpel, in *uRALP Workshop*, 1st Russian-German Conference on Biomedical Engineering (RCG), Hanover, Germany, 2013.
6. **L. Fichera** and L. S. Mattos, Towards Cognitive Supervision in Robot-Assisted Surgery, in *Workshop on Robot-Assisted Laryngeal Microsurgery*, 4th IEEE International Conference on Biomedical Robotics and Biomechatronics (Biorob), Rome, Italy, 2012.
7. **L. Fichera**, D. Marletta, C. Santoro, and V. Nicosia, A Methodology to Extend Imperative Languages with AgentSpeak Declarative Constructs, in *11th National Workshop “From Objects to Agents” (WOA)*, Rimini, Italy, 2010.

#### **Books**

1. **L. Fichera**, Cognitive Supervision for Robot-Assisted Minimally Invasive Laser Surgery. Springer, Apr. 2016, PhD Thesis, ISBN: 978-3-319-30329-1.

#### **Book Chapters**

1. L. S. Mattos, D. Pardo, E. Olivieri, G. Barresi, J. Ortiz, **L. Fichera**, N. Deshpande, and V. Penza, Microsurgery Systems, in *The E-Medicine, E-Health, M-Health, Telemedicine, and Telehealth Handbook*, H. Eren and J. Webster, Eds. CRC Press, 2015.

2. Y. Nguyen, N. Gerber, M. Caversaccio, S. Weber, L.A. Kahrs, O. Majdani, N. Dillon, **L. Fichera**, R.F. Labadie, Robot-based otological surgery, in *Robotics and Digital Guidance in ENT-H&N Surgery*, B. Lombard and P. Ceruse, Eds. Elsevier, 2017.

### Invited Presentations

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1. University of New Hampshire, *Rise of the machines in the Operating Room: Using AI to build smarter, more dexterous surgical robots*. March 2018.

### Teaching

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2. **Unified Robotics III: Manipulation**. This is an undergraduate (junior-level) focused on the control of robotic manipulators. Topics covered: position kinematics, differential kinematics, kineto-statics duality, fundamentals of dynamics, path planning, trajectory generation, image-based tracking. The course involves laboratory sessions wherein students implement the models/algorithms learned in the classroom (Sample student video submission: <https://www.youtube.com/watch?v=BBPJMZfkOqI>). *WPI: C term 2018, enrollment: 45*.
3. **Advanced Surgical Robotics [under development]**. This graduate-level (special topic) course is targeted at aspiring surgical robotics researchers. The goal of the course is to introduce students to the latest developments in the field of surgical robotics and serve as a catalyst for new surgical robotics research at WPI. Topics to be covered include: fundamentals of computer- and robot-assisted surgery, fundamentals of medical imaging and image-guided procedures, design modeling and control of continuum flexible robots for surgical applications, surgical robotics autonomy. *WPI: A term 2018*.

### Advising

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**Zhitao Li**, MS 2019, WPI

**Directed Research** Project: Design optimization of a miniature steerable robotic endoscope

**Mike Sokolovsky**, MS 2018 (co-advised with Andrea Arnold), WPI

**Directed Research** Project: Modeling of temperature increase in laser-irradiated biological tissue.

**Andre Imperiali**, BS 2018, WPI

**Major Qualifying Project (MQP)**: Design and Implementation of a Manufacturing Process to create Nitinol Flexure Wrists for use in Medical Applications.

**Kirsten Herchenroder, Spenser Martin, Connor Mastropoli, Maria Perez Luna, Silvio Torres**, BS 2018, WPI (co-advised with Greg Fischer and Tiffany Butler)

**Major Qualifying Project (MQP)**: Dynamic Correction of Postural Kyphosis

**Ankur Agrawal**, MS 2018 (co-advised with Greg Fischer), WPI

**Thesis title**: Automating endoscopic camera for teleoperation using Reinforcement Learning

**Shan Lin**, MS 2017, Vanderbilt University - *now a PhD student at the University of Washington*

Thesis title: Miniature Infrared Thermography System for Thermal Monitoring and Controlling of Vessel Sealing

**Mitch Fulton**, BS 2017, Anderson University - *now a PhD student at the University of Colorado-Boulder*

Project title: Development of a methodology to learn and predict the temperature dynamics created by the application of heat to tissue during medical treatment

### Thesis and Exam Committees

2017: Meagan Hiatt (WPI, M.S.)

2018: Marek Wartenberg (WPI, Robotics Ph.D.), Christopher J. Nycz (WPI, Robotics Ph.D.), Katie Gandomi (WPI, Robotics M.S.), Anna Novoseltseva (WPI, BME M.S.), Payam Razavi (WPI, ME Ph.D.)

### Professional Service

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#### International Conference Organization and Review Committees

2017: Proposal Review Panelist for the National Science Foundation (NSF)

2018: Proposal Review Panelist for the Department of Defense (DoD) - CDMRP  
Associate Editor for Workshops, IEEE BIOROB

#### Technical Reviews

I have reviewed many papers for the following Journals and Conferences:

IEEE Robotics and Automation Letters

Journal of Medical Robotics Research

Applied Physics Part B: Lasers and Optics

IEEE International Conference on Robotics and Automation (ICRA)

IEEE International Conference on Multisensor Fusion and Information Integration (MFI)

IEEE Engineering in Medicine and Biology (EMBC)

IEEE International Conference on Biomedical Robotics and Biomechatronics (BIOROB)

### Industrial Experience

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Jan – Jul **Storage Administrator**, Autostrade per l'Italia SpA, Florence, Italy

2011 Administration of the company's Storage Area Networks (SANs)  
Maintainance of the company's storages systems (IBM, EMC2)

Oct – Dec **Software Engineer**, Jurma Srl, Catania, Italy

2011 Design and development of a distributed monitoring system for photovoltaic power stations. Technologies involved: Erlang/OTP and MySQL  
GNU/Linux system administration

### Contact Information

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