FRED LIVINGSTON, PH.D.
PRINCIPAL ROBOTICS ENGINEER
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CONTENTS

INTEREST

My research involves the advancement of cyber-physical systems for autonomy. These systems utilized multi-agent robotics technologies, decentralized control, sensor fusion, optimal motion planning, edge computing, reinforcement learning, blockchain, smart contracts, and security.

"I'm excited to bring my 20 years of experience in the autonomy industry and multiple patents and commercial products into academia."

EARNED DEGREES

- **Ph.D.** North Carolina State University, Raleigh
  Electrical and Computer Engineering (2014)
  Dissertation: ' Development of A Wireless Ultrasound System for Industrial, Medical, and Military Applications '

- **M.S.** North Carolina State University, Raleigh
  Electrical and Computer Engineering (2006)
  Thesis: ' Development of an Internet Addressable Pneumatically Controlled Instrument for Applying Strain to Cells In-Vitro '

- **B.S.** North Carolina State University, Raleigh
  Electrical and Computer Engineering (2003)
  Senior Design: ' Colony of Robots Communications Framework '

EMPLOYMENT HISTORY

Industry Appointments

SECMATION, Raleigh NC

Principal Robotics Engineer [2021 - present]
Real-time control architectures for rapidly developing secured unmanned systems. Research topics include:

- Secured architecture for rapid deployment of ROS-M, ROS2, and MATLAB algorithms to unmanned vehicles
- Design and implementation of an Integrated Development Environment (IDE) for the rapid development of secured unmanned systems
- Development of Group 2 multi-motor vehicles
- Electrical Design of a modular integrated Autopilot and System on Module (SOM)
- Integration and testing of adaptive control algorithms
- Project manager and point of contact for Phase 2 SBIR with the Office of Naval Research (ONR). Code 351 Air Warfare and Weapons
- Manage summer internship program
- Support integration efforts with the Navy Autonomy Research Arena (ARA, China Lake)
- Support integration efforts with Naval Air Warfare Center Weapons Division (NAWCWD)

MECHASPIN, Lake Mary FL

Senior Robotics Engineer [2018 - 2021]
Research and develop perception and control algorithms for large-scale robotics systems. Contributions include:

- 3D LiDAR system integrations (Velodyne, Ouster, Quanergy)

- Deep Learning algorithms for real-time object detections and tracking using 3D point clouds
- Kinematics and dynamic modeling of robotic manipulators.
- Robotic simulation using ROS/Gazebo and Unreal gaming engine.
- NVIDIA GPU enhances edge device processing (Jetson Nano, Xavier)

Project sponsor by ONR, Code 33 Advance Naval Platforms

OLAERIS, Raleigh NC

Research and Development Engineer [2016 - 2018]

Developed large-scale unmanned aerial systems designed specifically for domestic emergency services.

- Electrical and firmware design of power management system for large-scale UAS platform: Analog and digital prototyping and design real-time current, temperature, and voltage using ATMEGA processor and custom PCB.
- Development of wireless communication system and algorithm for beyond line of sight navigation and control using C++, Python
- Algorithm for self-docking and charging
- Project management of capstone projects with the North Carolina State University and North Carolina Agricultural and Technical State University
- Head of the flight operation for unmanned system

Sandia National Laboratories, Albuquerque NM

Mechanical Engineer, Graduate Internship [2004 - 2006]

- Finite Element Analysis (FEA) of raw materials for laser forming
- Designed, assembled, and tested a mesoscopic-scale radio frequency switch using advanced CAD tools, modeling techniques, LabVIEW, robotic manipulators, and advanced vision systems.

Academic Appointments

NORTH CAROLINA STATE UNIVERSITY, Raleigh NC

- Adjunct Assistant Professor, Department of Electrical and Computer Engineering [Spring 2022 - present] [Spring 2015, 2019]
- Post-Doctoral Fellow, Institute for Transportation Research and Education [2014 – 2015]
- Graduate Research Assistant, Department of Electrical and Computer Engineering [2003 – 2014]

As Adjunct Assistant Professor, I develop and teach courses associated with the Control, Robotics, and Mechatronics (CRM) concentration within the ECE Department. As a post-doctoral fellow, I investigated the use of Unmanned Aerial Systems for the N.C. Department of Transportation). Contributions include:

- Non-metric camera photogrammetry survey in challenging terrains.
- UAS flight planning using GIS tools such as GRASS, Google Earth, ArcMap
- Command and control of UAS in GPS-denied environments
- Investigation of human-assisted flight control of unknown domains using Parallel Tracking and Mapping (PTAM) implemented on the Robot Operating System (ROS)
- 3D Model reconstruction from aerial imagery using Structure for Motion (STM)
- Best practices for integration with manned and unmanned airspace

As a graduate assistant for the Center of Robotics and Intelligent Machines, I was involved in developing a colony of unmanned autonomous vehicles for environmental monitoring. The project involved the fusion of sensor data from multiple robots to complete a common task. Responsibilities included:

- Hardware, mechanical, and electrical design of wireless sensors.
- Developing control algorithms for autonomous navigation.
- Development of a Human-Machine Interface for prosthetic limb control; this research involves biomedical instrumentation, machine learning [neural networks], mechatronics, and control theory.

DUKE UNIVERSITY, Durham NC

Adjunct Assistant Professor, Department of Mechanical Engineering and Materials Science [Fall 2019]

As an Adjunct Assistant Professor at the Pratt School of Engineering, I developed and managed a graduate-level course on the design and control of robotics systems. The course was split into two halves, with the first half focusing on theory and the second half on applications. In the first half of the course, students learned about kinematics, dynamics, and control topics. In the second half of the course, students applied these concepts to design and build their autonomous robots. The course was a great success, with students consistently rating it highly. I was also pleased that many students continued to work on robotics projects after the course ended.

ECPI University, College of Technology, Raleigh NC

Teaching Instructor, Electronics Engineering Technology [2016 - 2017]

As a faculty member in Electronics Engineering Technology, I had the opportunity to teach and mentor students in an accelerated five weeks curriculum. I have mentored online and in-seat students in this curriculum, which has been an excellent experience. The online students can complete the coursework at their own pace, and the in-seat students can complete the coursework in a more traditional classroom setting. I have found that both groups of students benefit from my mentoring. The mentoring I provide helps the students understand the material, apply the material to real-world situations, and become better engineers.

GRANTS AND CONTRACTS

[G.1] SecMUAS – Secure Modular Unmanned Aerial System
The goal of the SecMUAS program is to enable the rapid, modular, security-enhanced unmanned systems design process
Customer: Office of Naval Research. Code 351, Air Warfare and Weapons
ONR POC: Brian Holm-Hansen, Ph.D (brian.holm-hansen@navy.mil)
P.I.: Hal Aldridge, Ph.D. (hal@secmation.com)
Co-Pi: Fred Livingston, Ph.D. (fred.livingston@secmation.com)
Phase II SBIR: $1 M; March 2021 – July 2022
Phase II SBIR Option: $1M; July 2022 – December 2023

HONORS AND AWARDS

- Emerald Literati Network Outstanding Paper Award (2007)
- Microsystems and Engineering Sciences Applications (MESA) Institute Fellow (2004, 2006)
- National Science Foundation Minority Graduate Education Fellowship (2003)

TEACHING

Courses Taught

- **Introduction to Modern Industrial Automation**, NCSU

This course covers industrial automation theory and practice in the modern industrial environment. It is designed to give students a thorough understanding of industrial automation control systems, including programmable logic controllers (PLCs), robot manipulators, sensors, motor drives, and industrial networks to achieve Industrial 4.0. Industrial Automation applications must be developed and demonstrated with modern, data-driven manufacturing systems that collaborate in real time. For instance, a PLC-controlled assembly, combined with data acquisition industrial communication, such as via OPC UA technology, and robotics, such as a robot manipulator properly integrated into the IoT (Internet of Things). Through this collaboration, data can be released in the Core data model exchanged between systems and machines in different locations to provide new opportunities to increase productivity efficiently and cost-effectively. This course provides the fundamental theory of modern industrial automation, including hands-on laboratory experience and a final course project.

- **Mechatronics**, NCSU

This course introduces students to the study of electro-mechanical systems controlled by microcontroller technology. The course covers the theory, design, and construction of intelligent systems, closely coupled and fully integrated products, and methods. The course also covers the synergistic integration of sensors, interfaces, actuators, microcontrollers, and control technology. This course allows students to learn about the latest developments in electro-mechanical system microcontroller technology and how to apply this knowledge to real-world problems.

- **Computer Control of Robotics**, NCSU

This course teaches the principles of the design and control of robotic systems. It will have the ability to the mathematical model and develop algorithms to produce "intelligent" sensor-based behavior. This course includes modern-day robotics topics such as Robot Operating Systems (ROS) and advanced simulation using MATLAB and Gazebo.

- **Industrial Robotics**, NCSU, and Duke

Senior-level undergraduate course 'Robotic Systems' Topics include mathematical modeling and simulation of industrial planar robots, forward and inverse kinematics, velocities, and trajectory. This course was also taught remotely to UNC Asheville through the distance education program.

- **Programming Concepts**, ECPI University

This course introduces the C programming language using the Microsoft Visual Studio Environment. Topics included Control structures and Functions, Arrays and Pointers, Strings and Characters, Structures and Unions

- **Industrial Applications**, ECPI University

This course covers the basic principles of Silicon-controlled rectifiers and motor control circuits. Students learned about process control system concepts and various sensor technologies.

- **Microcontrollers**, ECPI University

This course covers the fundamental principles of Microcontroller technologies. Students were introduced to HCS12 Microcontrollers and embedded systems. Topics covered include architecture, memory map, I/O interfacing, and interrupts. Application projects are an integral part of the course requiring programming and interfacing with electronic circuits.

- **Programmable Controllers and Robotics**, ECPI University

This course covers advanced principles of control systems. Students were introduced to industrial control and statistical process control concepts. Sensor applications and Hands-on applications in programming and troubleshooting Programmable Logic Controllers are emphasized.

- **Circuit Analysis**, ECPI University

This course covers network theorems. Students learned about electrical circuit analysis using circuit theorems; node-voltage, mesh current, Thevenin, and Norton theorems. Students were introduced to dependent source models. Transient and steady-state circuit analyses are covered.

- **Instrumentation and Measurement**, ECPI University

This course concentrates on electronic instrumentation and measurement tools. Topics covered include errors, sensors and transducers, and signal conditioning. An extensive hands-on laboratory experience introduced the students to different electrical and electronic measuring devices set up and used for component and board-level troubleshooting and repair.

Individual Student Guidance

- Qingyu Geng (advisor Eddie Grant) [present]

Student in the department of Electrical and Computer Engineering, utilizing machine learning, advanced control, and cyber-physical system for autonomous control of healthcare devices.
Dissertation Title: Smart human-machine interface for autonomous wheelchair

Other Teaching Activities

- Mechanical Engineering Senior Design Project (2022) – Assist a senior design team in the design and control of a legged robot to explore unknown terrain.
- Wake Forest University Senior Design Projects (2021) – Integration of 3D LiDAR into a multirotor for vegetation surveys

COMMERCIALIZATION

- **Flexcell FX5000** [2006]

  The FX5000 is a biomedical tissue engineering product developed through my master's dissertation. This pneumatic cell stretching bioreactors system uses vacuum pressure to enhance your ability to research cellular mechanics by creating in vitro models and 3D tissue constructs within the optimal simulated in vivo environment for cell proliferation and growth.

- **Carolon's SmartSleeve** [2014]

  SmartSleeve integrates engineering into textiles to treat vascular disorders by sensing and adjusting the compression to a wound. This patent technology was made commercially available by the Carolon Company.

SERVICE

- IEEE Senior Member (In-Progress 2022)
- IEEE Eastern North Carolina Robotics and Automation Society Chapter President (2020 – 2021)
- Association for Unmanned Vehicle Systems International (AUSVI) – Member (2020 – Present)
- IEEE Sensor Council, Social Media Chair (2015)
- IEEE International Conference on Intelligent Robots and Systems (IROS) Web Administrator (2007)

CERTIFICATIONS

- USF Certification in Grant Writing (Schedule Summer 2022)

- Deep Learning for Robotics - NVIDIA (2020)
- ED101 Effective Teaching Strategies − Center for Excellence in Education (2017)
- ED102 Student Retention Methods − Center for Excellence in Education (2017)
- ED109 Preparing and Creating Lesson Plans − Center for Excellence in Education (2017)

SCHOLARLY ACCOMPLISHMENTS

Patents

Wireless Communication between an operator of a Remotely Operated Aircraft and a Controlling Entity

US 10205508 · Issued Feb 12, 2019

The present invention extends to methods, systems, devices, apparatus, and computer program products for wireless communication between an operator of a remotely operated aircraft and a controlling entity. A communication converter at a remotely operated aircraft converts between radio communication (e.g., VHF airband) and communication over another wireless network (e.g., over a cellular network). Thus, aspects of the invention can be used to facilitate (e.g., more localized) radio communication between an operator (e.g., pilot) of a remotely operated aircraft and a controlling entity (e.g., a control center) when the operator (e.g., pilot) is physically located outside of (e.g., VHF) radio range from the controlling entity. Accordingly, a two-way voice communication link can be established between the operator and personnel at a control center.

The Binary Encoding of Sensors in 2D and 3D Knitted Structures
U.S. 20170233902A1 · Issued Dec 17, 2019

A system and method comprising binary coding in a textile structure can include a textile sensor configured to sense a property and have a yarn pattern. A binary code can be associated with the yarn pattern. When the textile sensor senses the property, the property alters the relative positions of yarns in the yarn pattern, causing the associated binary code to change. A particular change in the binary code represents a defined value of the property. As a result, a second textile sensor having a second yarn pattern can be designed based on the unique binary codes of the first textile sensor measurements, such that the second textile sensor provides predictable responses to different property values.

Refereed Conference Publications

[C.4] H. Aldridge and **F. Livingston**, "Rapid Development of Secure Robotic Platforms," in *Future Force Capabilities Conference and Exhibition*, Austin, Texas, 2022

[C.3] **F. Livingston** and E. Grant, "A Design and Modeling Software Tool for Prototyping for Ultrasonic Transceivers," in *IEEE Sensor Conference*, Dallas, Texas, 2022

[C.2] H. Aldridge and **F. Livingston**, "Secure Rapid Prototyping for Unmanned Systems," in *NDIA Ground Vehicle Systems Engineering and Technology Symposium*, Novi, Michigan, 2021.

[C.1] **F. Livingston**, E. Grant, and G. Lee, "On the Design of a KANSEI Robot Testbed for Understanding Human Machine Interaction," in *International Conference on KANSEI Engineering and Emotion Research*, Paris, France, 2010.

Refereed Journal Articles (In-review)

[J.D] **F. J. Livingston** and E. Grant, "A Design and Modeling Software Tool for Prototyping Ultrasound Transceivers," submitted to *IEEE Sensors Journal in 2022.*

[J.C] **F. J. Livingst**on and E. Grant, "Wireless, Wearable, and Real-Time Vasculatory Signal Processing and Diagnostics," submitted to *IEEE Engineering in Medicine and Biology Society in 2022.*

[J.B] **F. J. Livingston**, E. Grant, and M. Hegarty-Craver, "A Wearable System that Monitors and Adaptively Controls Compression to Patients Suffering from Vascular Insufficiency," submitted to *IEEE/ASME Trans on Mechatronics in 2022.*

[J.A] **F. J. Livingston** and E. Grant, "The Design and Development of an Ambulatory Wireless Broadband Ultrasound Transceiver," submitted to *IEEE Sensors Journal in 2022.*

Refereed Journal Articles

[J.2] **F. Livingston**, M. Craver, M. Hegart-Craver, S. McMaster, Edward Grant, "Characterizing conductive yarns for pressure sensors applications," in *IEEE SENSOR*, 2015.

[J.1] J. A. Palmer, B. Jokiel, C. D. Nordquist, B. A. Kast, C. J. Atwood, **F. J. Livingston**, E. Grant, F. R. Medina, and R. B. Wicker, "Mesoscale R.F. relay enabled by integrated rapid manufacturing," *Rapid Prototyping Journal,* vol. 12, no. 3, 2006.

- Emerald LiteratiNetwork Outstanding Paper Award (2007)

Other Publications (Dissertation)

[D.2] **F. J. Livingston**, "Technology for Improving the Quality of Life for Patients Suffering from Vascular Insufficiency," North Carolina State University, Raleigh, 2014.

[D.1] **F. J. Livingston**, "Development of an Internet Addressable Pneumatically Controlled Instrument for Applying Stain the Cells In-Vitro," North Carolina State University, Raleigh, 2006.

Presentations

[P.6] M. Hegarty, **F. J. Livingston**, E. Grant and L. Reid, "*A Wearable Monitoring System for Continuously Assessing the Health of the Peripheral Vasculature," MedTech, 2010*

[P.5] **F. J. Livingston**, "Implementation of Breiman's random forest machine learning algorithm," North Carolina State University, 2005.

[P.4] **F. J. Livingston**, "A Network-Based Vacuum Control System for Tissue Engineering Stimulation," An oral presentation at the NCSU 2nd Annual Graduate Student Association Seminar, Raleigh, North Carolina, August 27, 2005.

[P.3] **F. J. Livingston**, "Technology for Mesoscopic-scale Assembly of R.F. Switch," An oral presentation at Sandia National Laboratories 9th Annual Symposium, Albuquerque, NM., August 2, 2004.

[P.2] **F. J. Livingston**, " Communications Framework for Colony of Autonomous Robots," A presentation at 17th National Conference on Undergraduate Research. Salt Lake City, UT., March 15, 2003.

[P.1] **F. J. Livingston**, "Interfacing MOCASIn-II," II' A presentation at 2nd Annual OPT-ED (North Carolina Alliance to Create Opportunity through Education) Alliance Day, Raleigh, NC. November 21, 2003.