

# Juan David Gamba Camacho

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## Personal Information

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## Education

- 2018–2021 **Doctor of Philosophy - PhD in Advanced Robotics**, *Dipartimento di Informatica, Bioingegneria, Robotica e Ingegneria dei Sistemi*, Università degli Studi di Genova, Italy.
- 2016–2018 **Master's Degree, Electrical Engineering**, *Departamento de Engenharia Eletrica*, Pontificia Universidade Catolica do Rio de Janeiro, Brazil.
- 2012–2015 **Bachelor's Degree, Automation and Control**, *Escuela de Ingenieria Electronica*, Universidad Latina de Costa Rica, Costa Rica.
- 2010–2012 **Associate's Degree, Electronics and Communications Engineering**, *Escuela de Ingenieria Electronica*, Universidad Latina de Costa Rica, Costa Rica.

## Achievements & Honors

- 11/2015 **Winner of The National Award of Electronic Engineering, Professional Category - ASOELECTRONICA ITCR**, *Nationwide SCADA, Energy Quality, Instituto Costarricense de Electricidad*, Costa Rica. **News story.**

## Experience

2022–Present **Postdoctoral Researcher - Advanced Robotics & Dynamic Legged Systems Lab, Istituto Italiano di Tecnologia, Genova, Italy.**

In this position, I am mainly involved with leading the VINUM project (<https://vinum-robot.eu/>) and designing a low-level torque-control architecture applied to electric actuators (<https://dls.iit.it/robots> ).

### **VINUM project:**

- Develop an algorithm to perform 3D semantic segmentation of a grapevine using an RGBD camera combined with a neural network and a robotic arm. The algorithm uses the Open3D library and combines the depth information with clustering techniques based on the probabilistic outputs of the neural network and the ICP algorithm to obtain a clean and accurate 3D instance segmented plant model for manipulation purposes (pruning).
- Develop a control package to facilitate the pruning and camera motion planning and execution on the real robot thru Moveit Task Constructor.
- Design of computer-vision-based vineyard navigation strategy for quadruped robots. A student under my supervision implemented the navigation scheme on a real robot.
- Supervise students and fellows for the grapevine winter pruning projects.

### **Electric actuators:**

- Develop a real-time platform to execute different tests on electric actuators and test different control strategies. The system uses the sbRIO-9629 from NI, using the software LabVIEW, to control a motor driver via EtherCAT to achieve torque control in real-time.

2021–2022 **Research Fellow - Advanced Robotics, Istituto Italiano di Tecnologia, Genova, Italy.** During this period, I worked on the VINUM project (<https://vinum-robot.eu/>) project in tasks like:

- Improve the current perception and manipulation modules to increase the success in recognizing pruning points and reaching them with the end effector.
- Provide support to areas involving 2D semantic segmentation, data collection, system architecture, and manipulation control.
- VINUM Project website: <https://vinum-robot.eu/>

2018–2021 **Researcher PhD Student, Istituto Italiano di Tecnologia, Genova, Italy.**

During this period, I worked on the Skippy project. My main task consisted of developing a control strategy to balance the robot in the presence of spring-loaded passive motion freedoms. Skippy will have both a spring-loaded ankle and a spring in series with its main motor, and both springs are essential for Skippy to reach its performance objectives, so it was necessary to know how these springs affect balancing performance and how to make Skippy balance skilfully in the presence of these springs.

My tasks consisted in:

- Design of a balance controller for spring-loaded legged robots. The strategy enables the robot to perform high-performance motions and acrobatics accurately.
- Design a path planning algorithm based on an optimization strategy using casADI with orthogonal collocation methods to solve nonlinear programming (NLP) problems efficiently. This method can solve the NLP problem three times faster than multiple shooting methods.
- Design of a Non-linear observer to estimate the spring model of a spring-loaded legged robot. The strategy helps the robot to keep the balance and perform high-performance tasks using an unknown spring.

- o Design and implement the electronics schematic with embedded real-time controllers for performing experiments related to the project.
- o Design and implement the real-time embedded software for a test rig to explore the capabilities of IMUs (Vectornav VN-100, Bosch BNO055, LORD MicroStrain 3DM-GX5-15) working on bouncing applications, which are very common on legged robot applications. The software runs on the sbRIO-9637 development board from NI using the software LabVIEW, which has analog and digital inputs/outputs, a dual-core CPU, and a programmable FPGA. The FPGA oversees the performing:
  - o The SPI communication.
  - o The PWM low-level logic.
  - o The necessary signal conditioning.
 The board's CPU uses these measurements to control a solenoid and sends them to a host computer using network streams. Finally, this host runs a Human-Machine-Interface (HMI) to monitor online the acquired data.
- o Project website: <http://www.royfeatherstone.org/skippy/index.html>

2016–2018 **Master's Student & Research Collaborator**, *Pontificia Universidade Catolica do Rio de Janeiro*, Rio de Janeiro, Brazil.

During this period, I worked in different eye-in-hand visual servoing control schemes applied to a robotic harvesting task of soft fruits in the presence of parametric uncertainties in the system models.

- o A combination of position-based visual servoing (PBVS) to approach the end-effector to the fruit and an image-based visual servoing (IBVS) to control the gripper to harvest.
- o Develop a hybrid visual servoing (HVS) approach to fulfill the complete harvesting task by designing a suitable control law that combines error vectors defined in the image and task spaces.

For detecting the fruit, I used:

- o An algorithm based on the OHTA color space and Otsu's threshold method for fast detection of mature fruits.
- o A pre-trained deep encoder-decoder algorithm based on a minimized Segnet version for a fast and cheap inference during the task execution.

I also used the algorithms speeded-up-robust-features (SURF) and the-random-sample-consensus (RANSAC) or the Oriented FAST and Rotated BRIEF and the Brute-Force Matcher (BF-Matcher) to extract features from images and match them from to different scenes (obtained from a stereo camera) to do a 3D reconstruction of the target.

The software was implemented using ROS, a robot arm RV-2AJ, and a mini ZED stereo camera.

I also explore applying robust control techniques based on sliding mode to improve the system's robustness.

2015–2016 **Project Engineer - Security Solutions**, *Emerson Process Management*, Costa Rica.

- o Design and implement scripts for different applications involving embedded devices; for the Security US Team and providing support for various Power Water Solutions area projects.

2014–2015 **Project Engineer**, *Emerson Process Management*, Costa Rica.

- o Implementation, testing, and commissioning projects developed with Ovation (company software) provide technical support and on-site troubleshooting activities. Responsibilities included: Field Service Support; Project Engineering.

Projects:

- o Enertek, Mexico: Design and implement the control logic for Air Condensers and a Vacuum System for the full functionality of the Steam Turbine. Debug and configure the Modbus communication between the Alstom and SCADA systems.
- o Promissao and COG (Centro de Operação da Geração), Brazil: Field support for the maintenance of GU (Generation Unit) one and three. Configuration of WIN-911 (notifications, alarms, and events software). Configure the cybersecurity platform EDS.

2013–2014 **Intern Engineer**, *Instituto Costarricense de Electricidad*, Costa Rica.

- o Design and implementation of a nationwide SCADA on energy quality. The system has around fifty thousand variables using LabVIEW and the Data Logging and Supervisory Control module. The application consists of logging information via Modbus and other communications protocols from several sites distributed along with the country and storing it to be accessed by everyone through a public server.
- o The system was previously priced at approximately two hundred and fifty thousand dollars, and it ended up being developed by two engineering students in seven months.

## Scientific Publications

- 2022 **Computer-Vision Based Vineyard Navigation for Quadruped Robots** *4th Italian Conference for Robotics and Intelligent Machines, October 2022, Rome, Italy.*
- 2022 **Hopping, Landing and Balancing with Springs**, *PhD Thesis, Italian Institute of Technology and University of Genova, Advance Robotics Department, 2022, Italy.*
- 2021 **Balancing on a Springy Leg**, *IEEE International Conference on Robotics and Automation, June 2021, Xi'an, China.*
- 2021 **Robust Balancing Control of a Spring-legged Robot based on a High-order Sliding Mode Observer**, *IEEE-RAS International Conference on Humanoid Robots, July 2021, Munich, Germany.*
- 2018 **A Robust Visual Servoing Approach for Robotic Fruit Harvesting**, *Master Thesis, Departamento de Engenharia Elétrica, Pontifícia Universidade Católica do Rio de Janeiro, 2018, Brazil.*
- 2018 **A Robust Vision-based Control for Robotic Fruit Harvesting using Deep Learning**, *IEEE LARS 2018 - 15th Latin American Robotics Symposium, Brazil.*
- 2018 **A Visual Servoing Approach For Robotic Fruit Harvesting in the Presence of Parametric Uncertainties**, *CBA Proceedings Volumes, 2018. XXII Congresso Brasileiro de Automatica, Brazil.*

## Skills & Background Knowledge

### Computer skills

Java, HTML

VHDL, Assembler, LabVIEW, Solid Works, Power Shell, VBA, V-REP, ROS, CasADi,  $\LaTeX$ .  
C++, Python, Matlab, Linux, Windows, Microsoft Office.

### Soft skills

Problem Solving.

Adaptability.

Good ability in sharing and/or presenting ideas.

Very good team-work skills.

Friendly, sociable.

Versatile

## Research Interests

Control Theory: Linear and Non-linear Control, High Order Sliding Mode Observers and Dynamic Control.

Computer Vision: RGB-D Cameras, Stereo Cameras, 3D localization.

Optimal Control: Linear, Quadratic and Non-linear Programming.

Real-Time Embedded Programming.

Machine Learning: Reinforcement Learning, Deep Learning and Deep Reinforcement Learning.

## Languages

Spanish Mother tongue

English Advanced

Portuguese Intermediate

Italian Intermediate

*Fluent in communicative and academic aspect*

*Fluent in communicative*

*B2 Level*

## Interests

- Music

- Documentaries

- Sports

- Social Activities