JUAN PEDRO BOLÍVAR PUENTE

CTO · Consultant · Software Engineer

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Software engineer with a focus on music and interactive systems, architecture, user experience and design, programming languages, libre software and, ultimately, building systems and organisations that work for human beings.

Independent consultant helping teams in music technology, robotics, industrial software, AI and large-scale infrastructure modernise their architectures. Author of widely used C++ open source libraries (Immer, Lager, Zug). Regular speaker at international C++ and functional programming conferences. CTO at BRONZE.

Professional Experience

2020–present **Chief Technology Officer**, *BRONZE*, Remote, `https://bronze.ai`.

BRONZE reimagines the music creation and distribution process in order to bring the freshness and uniqueness of live music to the music we hear everywhere. Joined in 2020 as a consultant, CTO since 2022.

- Set up and managed the engineering and product team with 10+ people, defining the development process and leading architectural decisions.
- Designed, architected and built the next generation of the composition and arrangement software, enabling artists to make non-linear, generative and augmented music.
- Productised the technology stack, with a complete rewrite of the inherited prototypes to meet performance, scalability and productivity standards.
- Set the technical strategy and guided product decisions. Defined a modular architecture allowing third parties to leverage the BRONZE Engine, via HTTP services, Emscripten modules, Swift and C++ libraries.
- Implemented and deployed high-performance streaming systems scaling to tens of thousands of concurrent listeners of non-linear music.

2017–present **Founder and Software Engineering Consultant**, *Sinusoidal Engineering*, Remote, `https://sinusoid.al`.

Independent consulting practice focused on interactive systems, framework design, performance, modern C++ and open source/libre software. Much of the work centres on helping companies understand and implement *value-oriented design* and pragmatic functional programming principles in their C++ codebases, aided by my open source libraries Immer and Lager. Engagements typically combine hands-on architecture and implementation with mentoring of in-house teams.

Clients include: Darkmatter, Meta, Google, Steinberg, Ableton, Ipolog, BRONZE, Magnopus, Dusty Robotics, Plum, Kapela, Audulus, Prenav, OMICRON Energy, SoundX, WAVY and zenAud.io.

See Consulting services below.

2011–2016 **Software Engineer**, *Ableton*, Berlin, Germany.

Worked on *Push*, a digital hardware music instrument, *Live*, a leading digital audio workstation with millions of users, and research teams imagining future products. Small cross-functional teams using agile methods.

- Designed and built new systems, and rearchitected old legacy systems.
- Collaborated with designers and UX experts on user facing features.
- Mentored developers in modern C++, Python, and QML.
- Member of the architecture team overseeing and reviewing the evolution of the architecture across multiple teams of 30+ developers.
- Built prototypes in ClojureScript and Haskell.
- Bootstrapped the *Open Source Guild*, helping teams across the company (legal, business, engineering) understand and implement open source, in an ongoing effort to liberate multiple components.
- Represented Ableton at tech conferences, music hackathons and interviews.

2011 **Teacher, course in advanced Python**, *Instituto de Astrofísica de Andalucía*, Granada, Spain.
Taught a 25 hour course for astrophysics researchers and software developers working at the institute. Contents included object-oriented and functional programming, advanced topics and meta-programming, interfacing with C, testing automation and quality control, numeric computation, graphical interfaces with GTK and Glade, and web systems with Django. Materials: `https://sinusoid.es/python-avanzado`

2009–2011 **Research and teaching intern**, *Department of Computer Science and Artificial Intelligence*, University of Granada, Spain.
Worked on a *Teaching Innovation Project* with the Computer Vision Group and assisted in the course "Methodology of Computer Programming". Main developer of several *Moodle* modules and plug-ins adapting it to the department's processes, including new algorithm visualisations published in a collaborative and interactive ebook format. Released as libre software (`https://www.nongnu.org/cvg-moodle`) and presented at FINDTI'09 — *see Publications*.

2007–2008 **Systems administrator**, *Department of Applied Physics*, University of Huelva, Spain.
Installation and administration of GNU/Linux systems, Fortran development environments, the meteorological prediction models MM5 and WRF, and the particle dispersion model FlexPart.

Consulting Services

Selected engagements carried out through **Sinusoidal Engineering** since 2017.
More detail in the online portfolio: `https://sinusoid.es/do`

2026–present **AI and crypto infrastructure**, *Darkmatter*, `https://dm.sh`.
Darkmatter is an experimental lab working on software, protocols and trading infrastructure at the intersection of AI and crypto.

- Tech lead of *Nixmac*, a desktop application and AI agent for declaratively configuring macOS with Nix and Git, including a custom built harness interfacing with several LLM backends (some self-deployed).
- Reviewed and cleaned up *Stackpanel*, a Nix based development environment manager.
- Worked on crypto trading systems, including analysis tools for liquidity providing built in Rust, deployed on Kubernetes with ArgoCD.
- Rust, TypeScript, Nix and Kubernetes.

2026 **Streaming infrastructure**, *WAVY*.
Set up WAVY's streaming infrastructure using the BRONZE Engine, scaling to thousands of concurrent multichannel streams and easing integration into their Swift app. C++ and Nix. Shipped as *WAVY — Deep Listening* on the App Store.

2025 **Robotics monitoring and control**, *Plum*, `https://plum.build`.
Worked on Plum's robotics stack, bringing cutting edge automation workflows to construction sites. Helped clean up the software architecture, productise the tech stack, and improve the USD-based control, monitoring and visualisation tools. Built a C++ *Behavior Tree* library integrating with Lager, supporting both compile-time and runtime introspection with excellent performance. Rust and WebAssembly.

2024 **Graphics rewrite and mentoring**, *Dusty Robotics*, `https://www.dustyrobotics.com`.
Dusty builds robots that print building plans and layout on the floor of construction sites. Rewrote their plan viewer in Rust and WebGL, achieving orders of magnitude improvements in performance. Mentored their team in graphics programming, API design and software optimisation.

2023 **Immutable data structures at scale**, *Meta — Shard Manager team*.
Collaborated with the *Shard Manager* team, which was exploring Immer to improve performance. Added support for *transients* for maps and sets in Immer and mentored the team in the best use of immutable data structures. Deployed at scale on critical infrastructure serving millions of machines: average latency was lowered by an order of magnitude and memory usage halved.

2022 **Real-time audio engine optimisation**, *SoundX*, `https://www.soundx.fr`.
Addressed real-time programming issues, audio interfacing problems, sound glitches and other performance issues in their first prototypes.

2022 **Architecture review**, *Ipolog*, `https://www.ipolog.ai`.
Reviewed their strategy to use a value-oriented architecture for the application data model of their Qt application for designing complex industrial automation workflows, using Lager and Immer.

2021 **Data model rewrite**, *Steinberg — Cubasis*, `https://www.steinberg.net/cubasis`.
Reviewed and mentored the Cubasis team's rewrite of their whole data model using a value-oriented architecture. This improved the responsiveness of the app by decoupling the UI and data model threads, fixed long-standing bugs, and improved the overall maintainability and performance of the code. C++ and QML.

2021 **Real-time systems architecture**, *Magnopus*, `https://www.magnopus.com`.
Built a novel approach for film recording using robotics and on-set real-time 3D graphics. Designed the whole system's data-flow and communication architecture for real-time and low latency, using value-oriented actors built with Lager and Immer at their core. Built the scene visualisation and control software on top of USD, over UDP multicast and an EtherCAT engine.

2020 **Fuzzing infrastructure**, *Google — OSS-Fuzz*, `https://google.github.io/oss-fuzz`.
Integrated Immer into *OSS-Fuzz*, Google's continuous fuzzing service for infrastructure-critical open source software. Fuzz targets for the core data structures using novel techniques, and the build setup they run under.

2019–2020 **Rearchitecture and mentoring**, *Prenav*, `https://prenav.com`.
Rearchitected their structural inspection software using unidirectional data-flow with Lager. Mentored their team on value-oriented design and modern C++. Designed and built new core features.

2019 **Modernisation and development**, *OMICRON Energy*, `https://www.omicronenergy.com`.
Brought their C++ team up to date with modern development practices. Also worked directly on their partial discharge measurement software (MPD-800), introducing application-wide refactorings, a new immutable document model, and developing new features such as *user profiles*, allowing users to completely reconfigure their intricate UI to adapt to different use-cases and experience levels.

2019 **Document model and audio engine**, *Audulus*, `https://audulus.com`.
Helped this advanced modular synthesis app for iOS use value-oriented design principles in their next generation document model and audio engine. This improved performance, sped up the development process, and helped fix outstanding bugs.

2018–2019 **Development lead and architect, interim CTO**, *Kapela*, `https://kapela.live`.
Built and led the development team, set up the technical strategy and development process, architected and wrote much of the code behind Kapela, a system for connected performances offering a new way of experiencing live electronic music. C++, Rust, QML, Clojure and Nix.

2017 **Embedded Linux port**, *Ableton*, `https://www.ableton.com`.
Came back as a contractor to bring the core of *Live* to embedded Linux, the groundwork for the standalone *Push 3*: ported it and tuned its performance for the target board, tested it on the hardware, and built the first test images with Nix, before production moved to Yocto. C++ and Nix.

2017 **Graphics backend and architecture consulting**, *zenAud.io*, `https://zenaud.io`.
Built an OpenGL backend for their flagship live performance product and consulted to improve the overall UI architecture and audio engine, in order to achieve better performance and maintainability. C++ and Objective-C.

Libre Software Projects

Long-standing developer and advocate of libre software: author and maintainer of several widely used C++ libraries, past maintainer of several GNU packages, and co-founder of the techno-political *Hacklab Colina Roja* in Granada. Full portfolio: `https://sinusoid.es/do`

2016–present **Immer**, *Author and maintainer*, `https://sinusoid.es/immer`.
Postmodern immutable and persistent data structures for C++ — value semantics at scale. Implements cache-efficient structures such as RRB-Trees with several improvements of its own. Around 2.9k stars on GitHub, presented at ICFP'17 (*see Publications*) and deployed in production at Meta, Google, Amazon, etc.

2017–present **Lager**, *Author and maintainer*, `https://sinusoid.es/lager`.
A C++ library for value-oriented design using the unidirectional data-flow architecture — "Redux for C++". Brings the simplicity of the Elm architecture to C++, together with concepts from Clojure such as *cursors*, bridging the gap with OO-style components.

2019–present **Zug**, *Author and maintainer*, `https://sinusoid.es/zug`.
Transducers for C++: composable sequential transformations independent of the source, usable over both pull-based sequences (iterators, files) and push-based ones (signals, events, asynchronous streams).

2017 **Ewig**, *Author*, `https://github.com/arximboldi/ewig`.
The eternal text editor — a didactic ersatz Emacs showcasing immutable data structures and the single-atom architecture. Its undo/redo is ten lines of code, yet it can copy-paste a gigabyte of text without trouble.

2017 **Schmutz**, *Author*, `https://sinusoid.es/schmutz`.
SCHeMe UnterstüTZung — easy Guile Scheme bindings for C++ code via a simple embedded DSL, in the spirit of Boost.Python but for Scheme.

2014–2016 **Atria and Aqt.Cassowary**, *Ableton*, `https://github.com/ableton`.
Atria is a collection of core C++ libraries with an emphasis on functional programming and interactive immutable data models; its transducers module was presented at CppCon 2015. Aqt.Cassowary brings the Cassowary constraint solver to QML.

2007–2016 **GNU Psychosynth**, *Maintainer*, `https://psychosynth.gnu.sinusoid.es`.
A framework for modular, interactive and collaborative sound synthesis and live music performance, inspired by the ideas of the Reactable. Winner of the Spanish Inter-University Free Software contest in 2008.

2004–2012 **GNU Jump**, *Maintainer*, `https://jump.gnu.sinusoid.es`.
An addictive arcade game, developed during High School on top of the code of the earlier Luciferino project.

2006–2011 **GNU PDF**, *Contributor*, `https://www.gnupdf.org`.
Implemented the bidirectional *predictor* filters — awarded in an informal contest at the GNU Hackers Meeting in Ourense, 2007 — and LZW compression and decompression. Defined the binary compatibility policy and contributed several fixes and patches.

2010–2018 **Mixco and Mixxx**, *Author and contributor*, `https://sinusoid.es/mixco`.
Mixco is a framework for building advanced hardware controller mappings for the Mixxx DJ software in a literate and declarative style. Also a contributor to Mixxx itself, and maintained its M-Audio Xponent mapping.

Talks and Conferences

2025 **Persistence^2: persisting persistent data structures**, *CppCon (Aurora, USA), Meeting C++ (Berlin)*.
Presented `immer::persist`, a library allowing Immer data structures to be serialised or transformed while preserving their internal structure, including structural sharing across values.
`https://sinusoid.es/do/persistence-squared`

2019–2026 **Squaring the circle: value-oriented design in an object-oriented system**, *C++ Russia (Saint Petersburg), Meeting C++ (Berlin), C++ on Sea (Folkestone), std::cpp 2026 (Madrid)*.
How to bridge the impedance mismatch between object-oriented and value-oriented design. Allowing immutable data structures to be used in legacy systems and user interfaces written with traditional object-oriented toolkits, providing a path for modernisation.
`https://sinusoid.es/do/squaring-the-circle`

2018–2019 **The most valuable values**, *CppCon (Bellevue, WA), Meeting C++ (Berlin), std::cpp (Madrid)*.
Fundamentals of value-oriented design. Building a UI with a unidirectional data-flow architecture using Lager, including a time-travelling debugger.
`https://sinusoid.es/do/the-most-valuable-values`

2016–2019 **Postmodern immutable data structures**, *CppCon, ICFP, C++Now, C++ on Sea, C++ Russia, Meeting C++, Berlin C++ Meetup*.
Talks at multiple international conferences about immutable data structures and bringing them to C++ developers and systems programmers in general.
`https://sinusoid.es/do/postmodern-immutable-datastructures`

2015–2019 **Transducers: from Clojure to C++**, *CppCon (Bellevue, WA), EmBO++ (Bochum, Germany), CppCast*.
Presented the transducers module of Atria and its implementation, which is both very performant and less stateful than its Clojure counterpart. Also interviewed on CppCast Episode 39 about this work.
`https://sinusoid.es/do/transducers-from-clojure-to-c`

2017 **Programming: the last 4000 years**, *CppCon lightning talk*, Bellevue, WA, USA.
A personal commentary on the history of programming by analogy with the eras of western civilisation, advancing the conversation on what *modern* C++ is.
`https://sinusoid.es/do/programming-the-last-4000-years`

2015 **Share the code: open source music tech**, *Loop — Ableton Summit for Music Makers*, Berlin, Germany.
Organised and moderated a panel with Gianfranco Ceccolini (MOD Devices), Marije Baalman, Soledad Penadés and Paul Davis (Ardour, JACK) on the challenges and opportunities in open source music technology.
`https://sinusoid.es/do/share-the-code-open-source-music-tech`

2015 **Cooper: safe cooperative methods for Python**, *EuroPython lightning talk*, Bilbao, Spain.
`https://sinusoid.es/do/cooper`

2014–2015 **Modernize your C++**, *Berlin C++ Meetup and Ableton Dev Salon*, Berlin, Germany.
Through a provocative fable, discusses value semantics and non-intrusive polymorphism and introduces the Atria library.
`https://sinusoid.es/do/modernize-your-c`

2014 **C++ template metaprogramming**, *Ableton Dev Salon*, Berlin, Germany.
`https://sinusoid.es/do/c-template-metashyprogramming`

2013–2015 **Ableton Live Python API**, *SXSW Music Hack, MIDI Hack I (Stockholm) and II (Berlin), PyLadies Berlin*.

2010 **Desarrollo rápido de videojuegos con el panda y la pitón**, *Hackea y Lucha II, Hacklab Granada*, ETSIIT, Granada, Spain.
`https://sinusoid.es/do/desarrollo-rapido-de-videojuegos-con-el-panda-y-la-piton`

2009–2010 **Introducción al Software Libre**, *I y III Jornadas Contra el Pensamiento Único*, Facultad de Ciencias Políticas y Sociología, Granada, Spain.

2009 **Desarrollos sobre Moodle para la docencia de la informática**, *Congreso Fomento e Innovación con Nuevas Tecnologías en la Docencia de la Ingeniería (FINDTI)*, Vigo, Spain.

2008–2009 **ANSI C modular: librerías, polimorfismo y sistemas de plugins en C**, *Hackea y Lucha I, Hacklab Granada*, ETSIIT, Granada, Spain.
`https://sinusoid.es/do/ansi-c-modular`

2008 **GNU Psychosynth**, *Open Source World Conference (Málaga), Hackinvisible (Málaga), GNU Hackers Meeting (Bristol), Artquimia Music School (Málaga), Jornadas Comunidad Mórfeo (Granada), Territorios Festival (Sevilla), II Concurso Universitario de Software Libre (Sevilla)*.

Publications

2017 **Persistence for the Masses: RRB-Vectors in a Systems Language**, *Juan Pedro Bolívar Puente*, Proceedings of the ACM on Programming Languages, Vol. 1, ICFP, Article 16, 28 pages. Presented at ICFP'17.
Available on-line: `https://public.sinusoid.es/misc/immer/immer-icfp17.pdf`
DOI: 10.1145/3110260

2009 **GNU Psychosynth: A framework for modular, interactive and collaborative sound synthesis and live music performance**, *Juan Pedro Bolívar Puente*, Master's thesis, University of Granada, Spain.
Passed with Honours. Available on-line: `https://psychosynth.gnu.sinusoid.es/misc/pfc.pdf`

2009 **Desarrollos sobre Moodle para la docencia de la informática**, *Juan Pedro Bolívar Puente, J. Fdez-Valdivia, J. Martinez-Baena, A. Blanco, J. A. Garcia, A. Garrido and R. Rodriguez-Sanchez*, Congreso Fomento e Innovación con Nuevas Tecnologías en la Docencia de la Ingeniería, Vigo, Spain.
ISBN: 978-84-8158-463-9

2008 **GNU Psychosynth: Un sintetizador de audio por Software Libre**, *Juan Pedro Bolívar Puente*, Revista Novática, 195.
ISSN: 0211-2124

Skills

Leadership and Process

Technical leadership CTO of BRONZE since 2022. Team building and hiring, roadmap and technical strategy, cross-team architecture review. Managed teams of 10+.

Mentoring Regularly engaged to bring teams up to date with modern C++, functional programming and value-oriented design. Conference speaker and teacher.

Process Agile and Scrum, code review culture, CI and reproducible builds, testing automation, technical writing and documentation.

Areas of Expertise

Software architecture Value-oriented design, unidirectional data-flow, immutable and persistent data structures, domain modelling, modernisation of legacy code.

Graphics and interactive systems OpenGL, WebGL, USD, Qt/QML, SDL; real-time visualisation, UI frameworks, low-latency interaction.

Robotics and control Monitoring and control systems, behaviour trees, on-set and construction-site automation, low-latency communication.

Language design Programming language design and implementation: compilers, embedded DSLs, language bindings, metaprogramming.

Audio and music technology Real-time audio engines, DSP, synthesis, streaming infrastructure, MIDI, OSC, JACK, ALSA; DAW and instrument development.

Performance Profiling, cache-aware data structure design, memory management and reclamation, concurrency, benchmarking.

AI tooling LLM agent harnesses, integration with hosted and self-hosted model deployments, AI-assisted developer tooling.

Libre software GNU package maintainer; open source strategy, licensing and compliance, community building.

Programming Languages

C++ Expert, 20+ years. C++11 through C++23, template metaprogramming, generic and concept-based design, value semantics, lock-free and real-time safe code.

Python Expert. Scientific computing, tooling, GTK, Django, ctypes, NumPy. Taught an advanced Python course.

Rust Advanced. Systems and web (WASM) development, graphics, async, FFI.

QML Advanced. Declarative UI, Qt integration, custom rendering and constraint-based layout.

Functional Clojure/ClojureScript, Scheme/Guile, Haskell. Transducers, persistent data structures, parsers with Parsec, type-level programming.

Nix Advanced. Reproducible builds, packaging, cross-compilation, NixOS and nix-darwin deployments.

Web TypeScript, JavaScript/ES6, React, Reagent, CoffeeScript, HTML5/CSS3, WebAudio, WebGL.

Others C, Java, Bash, x86 assembly; some ML, Oz, Prolog.

Systems and Tools

GNU/Linux Long-term experience, mostly Debian based and NixOS; remote administration, basic kernel module development.

Build, VCS and deployment Git, CMake, Meson, Bazel, Nix flakes, Emscripten; Kubernetes and ArgoCD for GitOps deployment.

macOS and Windows Cross-platform development and deployment, code signing and packaging, nix-darwin.

Editors Daily GNU Emacs user.

Education

2006–2011 **Ingeniero Informático**, *ETSIIT, University of Granada*, Granada, Spain.
Master's level 5 year degree in Computer Science and Software Engineering, 300 ECTS credits.
Passed the final master's thesis with Honours — *see Publications*.
ECTS/GPA grading: A

2009–2010 **Erasmus Exchange**, *Åbo Akademi*, Turku, Finland.
Erasmus exchange during the fourth year of the degree.

2004–2006 **Bachillerato, specialised in technology**, *I.E.S. La Rábida*, Huelva, Spain.
Passed with Honours, awarded with a special scholarship.

Other Qualifications

2026 **Massage Practitioner — wellness massage, sports massage and myofascial trigger point therapy**, *Medios Seminare — Wellness Akademie*, Berlin, Germany.

2017 **telc Deutsch B2**, *telc*.
Common European Framework level B2 in German.

2006 **Ciclo superior de Inglés, Escuela Oficial de Idiomas**, *Huelva*, Spain.
Higher degree in English at the Official Languages School.

2005 **Course in the Advanced Administration of GNU/Linux Systems**, *University of Huelva*.
Passed with Honours.

2004 **Certificate in Advanced English**, *University of Cambridge*.

2003 **First Certificate in English**, *University of Cambridge*.

Languages

Spanish **Mother tongue**

English **Fluent** — *Fluent reading, writing and conversation. Working language for over 15 years; regular conference speaker. One year Erasmus exchange in Finland with most courses in English.*

German **Intermediate** — *telc Deutsch B2 certificate. Over a decade living in Berlin.*

Awards and Recognitions

2008 **Honour distinction of the School of Software Engineering**, *For his contribution to the external image of the School of Software Engineering and Telecommunications of the University of Granada*.

2008 **First prize, Comunidad Morfeo**, *Spanish Libre Software Contest for University Students*.
Awarded for the GNU Psychosynth project: `https://psychosynth.gnu.sinusoid.es`

2006 **Gold medal**, *Iberoamerican Contest in Informatics*.

2006 **First place**, *Spanish Olympiad in Informatics*.

2006 **Bronze medal**, *Spanish Olympiad in Mathematics*, national stage.

2006 **First place**, *Spanish Olympiad in Mathematics*, local stage, Huelva.

Interests

Massage Practitioner (see *Other Qualifications*).

DJ as *INTERNET.MP3* (`soundcloud.com/internet_mp3`),
earlier productions as *Arximboldi* (`soundcloud.com/magnicida`).

Amateur **powerlifting** (competed at Berlin RAW Strength 10.0 in Sept. 2026) and **painting**.