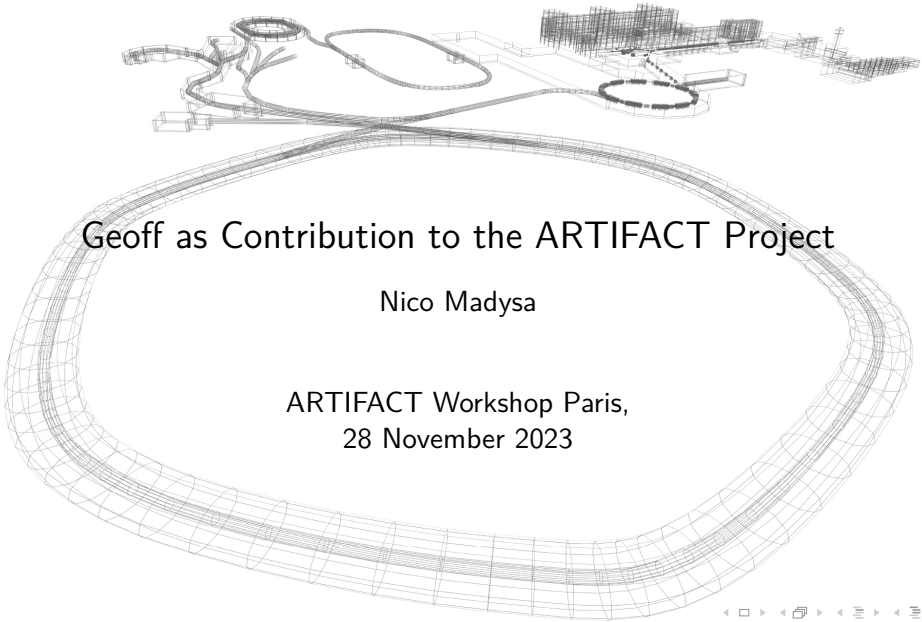


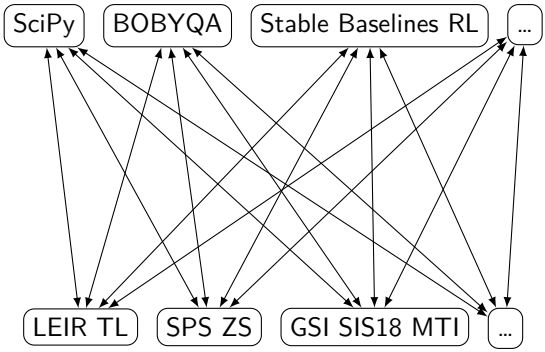
Geoff as Contribution to the ARTIFACT Project

Nico Madysa

ARTIFACT Workshop Paris,
28 November 2023

What is Geoff?

- a collection of Python packages
- most of the code: interfaces to standardize interaction between different third-party packages
- goal: reduce combinatorial complexity around solving optimization problems with different solvers and approaches
- in addition: Qt-based GUI application that ties all these interfaces together



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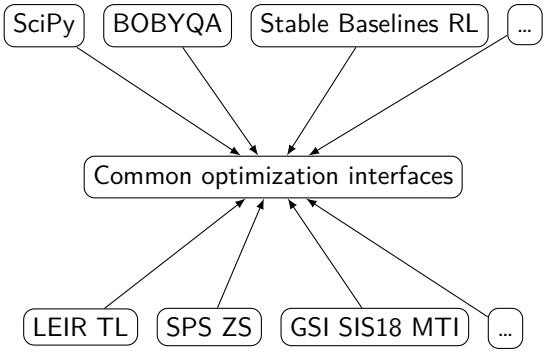
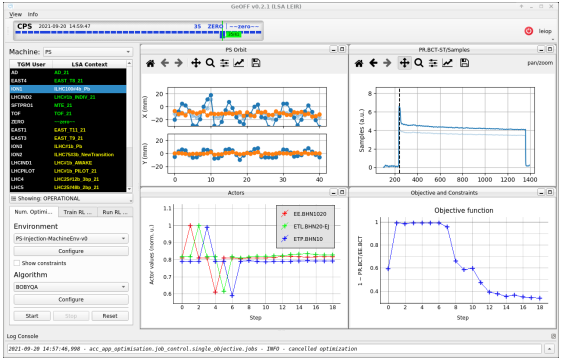


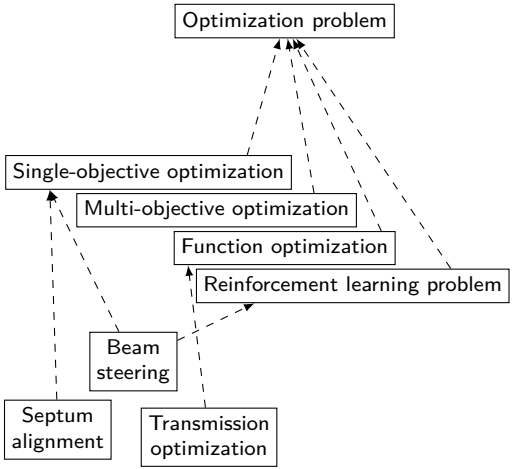
What is Geoff? ... an app



- prototype: lists, configures and runs optimization problems
- plugin mechanism for both optimizers and optimization problems
- live-updates custom plots during optimization
- soon: custom optimizers per problem (e.g. custom-tailored kernels for BO)

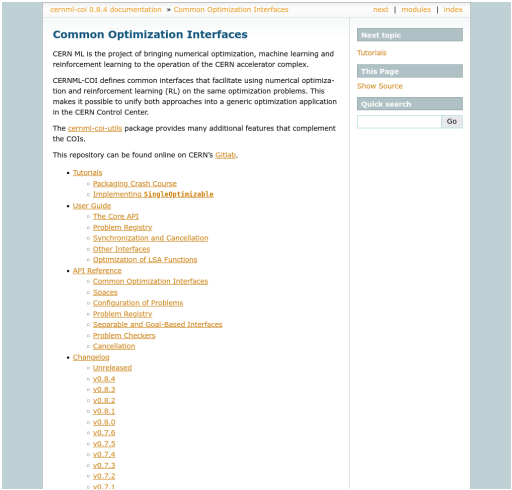
What is Geoff? ... a standard

- standardized interfaces and adapters for various packages
- based on Gymnasium RL interfaces
- extends them to numerical optimization
- extends their metadata system with accelerator-specific info



What is Geoff? … a standard

- standardized interfaces and adapters for various packages
- based on Gymnasium RL interfaces
- extends them to numerical optimization
- extends their metadata system with accelerator-specific info
- "20 % programming, 80 % documentation"


cernml-coi 0.8.4 documentation » Common Optimization Interfaces

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Common Optimization Interfaces

CERN ML is the project of bringing numerical optimization, machine learning and reinforcement learning to the operation of the CERN accelerator complex.

CERNML-COI defines common interfaces that facilitate using numerical optimization and reinforcement learning (RL) on the same optimization problems. This makes it possible to unify both approaches into a generic optimization application in the CERN Control Center.

The cernml-coi-utils package provides many additional features that complement the COIs.

This repository can be found online on CERN's Gitlab.

- Tutorials
  - Packaging Crash Course
  - Implementing `SingleOptimizable`
- User Guide
  - The Core API
  - Problem Registry
  - Synchronization and Cancellation
  - Other Interfaces
  - Optimization of LSA Functions
- API Reference
  - Common Optimization Interfaces
  - Spaces
  - Configuration of Problems
  - Problem Registry
  - Separable and Goal-Based Interfaces
  - Problem Checkers
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- Changelog
  - Unreleased
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  - v0.8.3
  - v0.8.2
  - v0.8.1
  - v0.8.0
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  - v0.7.4
  - v0.7.3
  - v0.7.2
  - v0.7.1

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Tutorials

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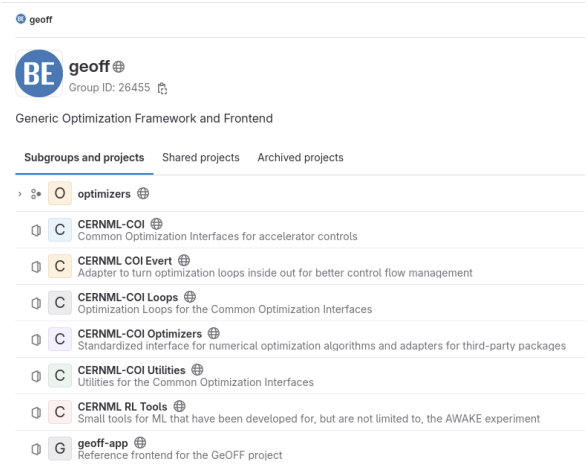
What is Geoff? ... an ecosystem



- not just a GUI!
- designed in a very modular way
- minimal interdependencies
- packages can be mixed and matched
- goal: enable each laboratory to design their own app
  - built from common components
  - tailored to their use case
  - easily learnable by newcomers
  - easily improved

What is Geoff? ... an approach to accelerator controls

Guiding principles:

- infrastructure for accelerator optimization and control
- empower machine experts and operators to solve problems and improve solutions

Methodology:

- be compatible with device access protocols, algorithms and environments
- minimize boilerplate code to keep cognitive load low
- always leave an escape hatch open in case of unexpected restrictions
- provide documentation to allow people to learn independently

What Other Frameworks Exist?

XOpt

- focus on Bayesian optimization
- configured with YAML/JSON files
- objective: stand-alone Python files (parameters described in configuration)

Badger

- fully fleshed out GUI frontend
- plugin structure similar to Geoff
- XOpt support via plugin
- can store and re-evaluate runs

Other, local efforts:

- CPS Optimizer at PS & ISOLDE
- Device Automator at GSI
- well tuned to their environment
- many are (impressive) one-person projects

How does Geoff compare?

The same:

- standardized interfaces + GUI for control room use
- open-source projects with institutional backing (SLAC and CERN+GSI resp.)
- derived from successful predecessor (OCELOT and OpenAI Gym resp.)

Geoff advantages:

- plugins may be Python packages
- modular and hackable
- more flexible
  - arbitrary configurability
  - support for nontrivial RDA
  - full matplotlib plotting
- upgrade path to RL

Geoff shortcomings:

- GUI needs more polishing
- no run management (yet)
- no data collection (yet)
- verbose for trivial optimization problems

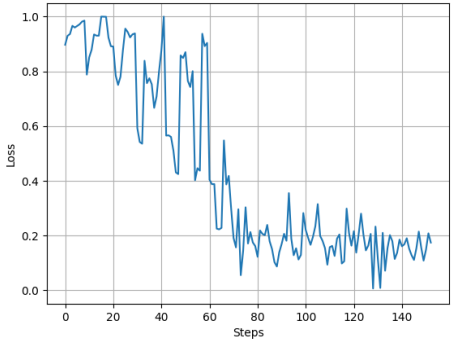
Adoption in 2023

State in 2022:

- 19 use cases at almost all CERN accelerators (not LHC or ISOLDE)

Developments in 2023:

- ISOLDE prototype developed
- use of Geoff on CERN's UCAP data-monitoring cloud
- pilot use of Geoff at GSI

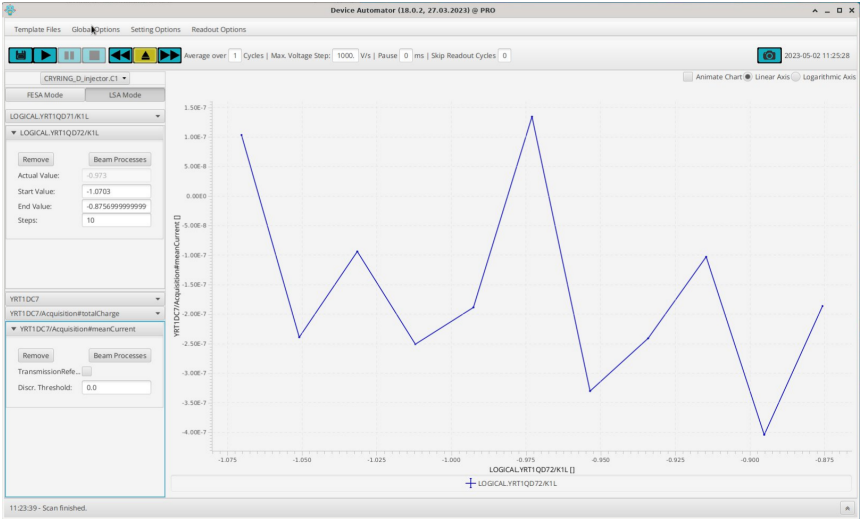


First use of Geoff to minimize beam losses in multi-turn injection of SIS18 at GSI

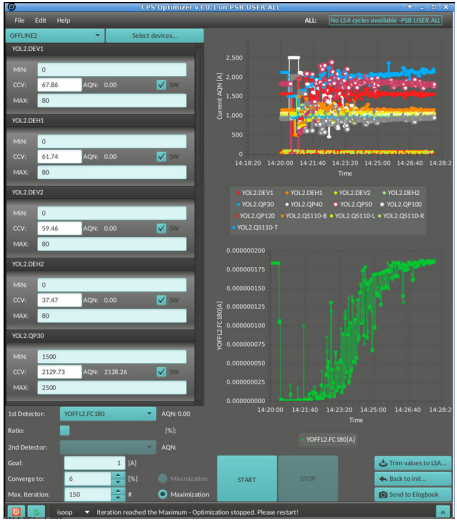
Contribution to ARTIFACT

- fundamentally an infrastructure project
- dissemination of Geoff *GUI app* has been funded by EURO-LABS (no overlap!)
- use, improve and extend Geoff modules to build WP 6 framework
- can be integrated with existing solutions due to focus on compatibility, openness and modularity

Backup



Device Automator, developed at GSI, used at CRYRING accelerator



CPS Optimizer, developed at CERN, used at ISOLDE OFFLINE 2 beamline