Peraton

Open Source Tools for SDR+ML

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TorchSig

A PyTorch Signal Processing Machine Learning Toolkit

Pretrained Models

TorchSig's API mirrors familiar libraries such as TorchVision and TorchAudio, providing the first ever toolkit that shares state of the art convolutional and transformer neural network models pretrained on complex-valued signals datasets.

Research & Development

Open-source code, datasets, and documentation enable community engagement for further advancing research and development in the field of signal processing machine learning.

Signals Datasets

TorchSig can generate and easily interface with the TorchSigNarrowband dataset, an augmentable dataset representing 60+ digital modulations commonly used in radio frequency communication signals, useful for signal classification research. TorchSig can also generate and interface with the TorchSigWideband dataset, a wideband extension to Narrowband, containing multiple signals in each data example, useful for signal detection and recognition research. TorchSig can be used as a standard in the open source community working with signals datasets.

Domain Transforms

Numerous complex signal augmentations, impairments, and expert feature transforms are provided and can be seamlessly customized and further developed.

- TorchSig is an open-source signal processing machine learning toolkit based on the PyTorch data handling pipeline.
- Some of the key features include: signals datasets, domain transforms, pretrained models, and open-source code and documentation for community research and development.

```
from torchsig.datasets.datamodules import NarrowbandDataModule
datamodule = NarrowbandDataModule(root="/workspace/code", impaired=False)
datamodule.prepare_data() # generates dataset to disk
datamodule.setup("fit") # creates dataset
data, label = datamodule.train[0]

from torchsig.models import EfficientNet1d
from torchsig.datasets.signal_classes import torchsig_signals
num_classes = len(torchsig_signals.class_list)
model = EfficientNet1d(2,num_classes)

import torchsig.transforms as ST
transforms = ST.AddNoise(noise_power_db=10)
```

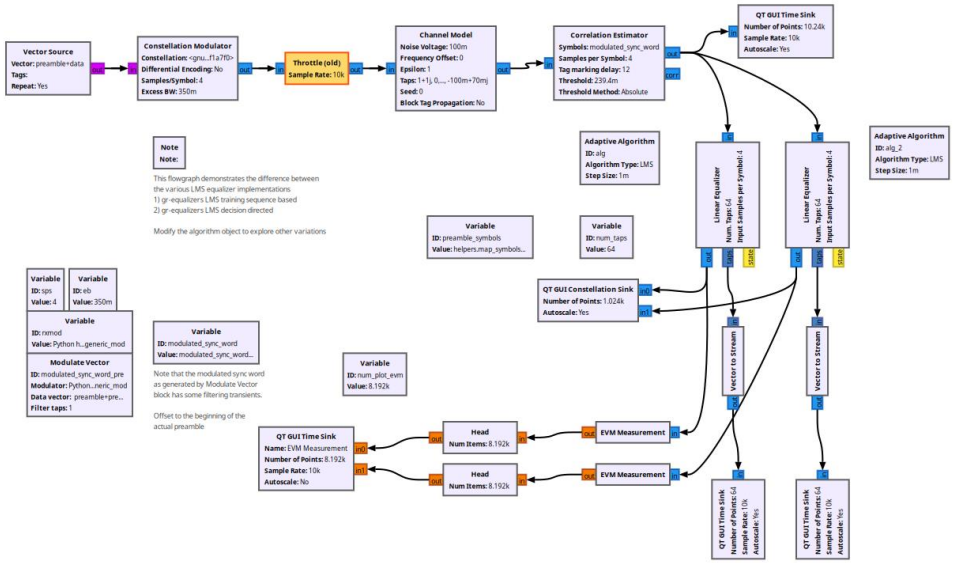
What is GNU Radio?

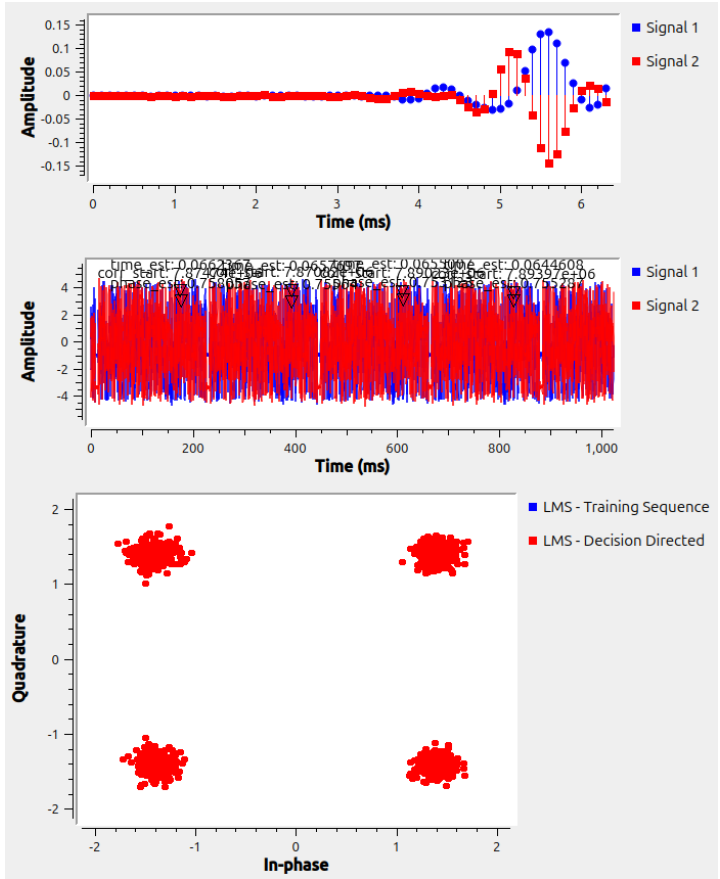
GNU Radio
THE FREE & OPEN SOFTWARE RADIO ECOSYSTEM

- A block-based signal processing library
- Out of the box integration with COTS radios
- Toolkit and framework to **build your own transceiver**

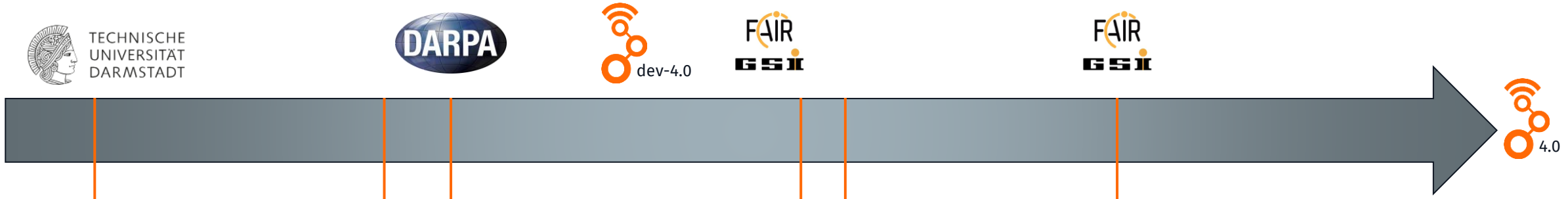
GNU Radio Companion (GRC)

- visual entrypoint into GNU Radio





GR 4.0 Timeline



2019: Benchmarking of GR scheduler, identification of optimization opportunities. Attempts to implement in current codebase

2020: newsched project - fresh start on architectural concepts

2020: SDR 4.0 - enhance GNU Radio capabilities on to heterogeneous compute platforms

2022: GSI/FAIR commits resources and takes on deeper changes to scheduler and API

2022: GRCon22 - newsched modularity and usability demonstration

2024: EU GR Days - @GSI/FAIR hands on workshops

2024: EU GR Days - Demonstration of packet modem in GR 4.0

Current State of GR 4.0

For GNU Radio to be used in critical infrastructure and real-world applications, it must meet higher standards for safety, cybersecurity, and product liability.

- Type Safety
- Modern C++ and Best Practices
- Lean, clean codebase

Maximize compute performance on modern CPUs by unleashing the power of modern compilers

- Lock Free buffers
- constexpr optimization
- std::simd standardization
- Block Merging

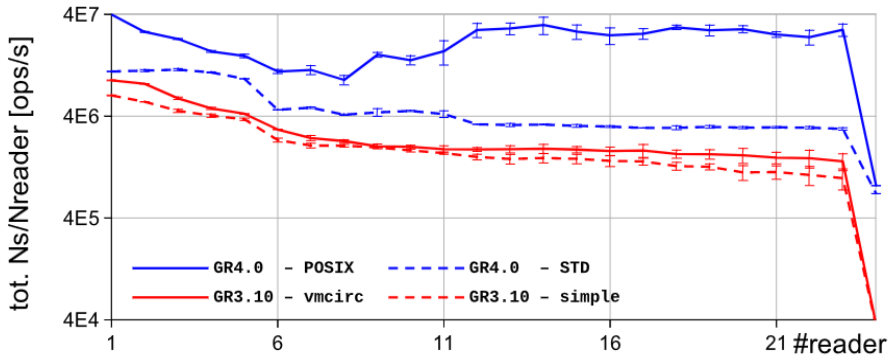
Improved Usability

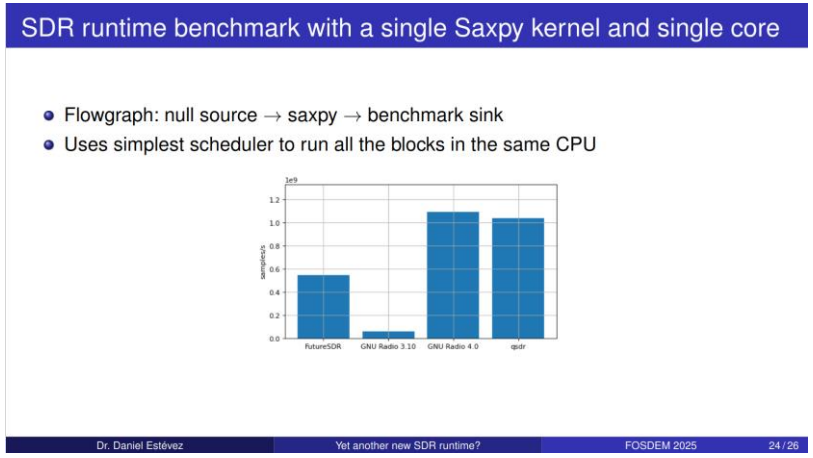
- User customizable schedulers
- Easy integration of heterogeneous, distributed, and embedded compute
- Asynchronous packet events a first class citizen
- More liberal licensing (LGPL currently agreed upon, open to other options)
- Simplified Block API

GR 4.0

Benchmarks and Applications

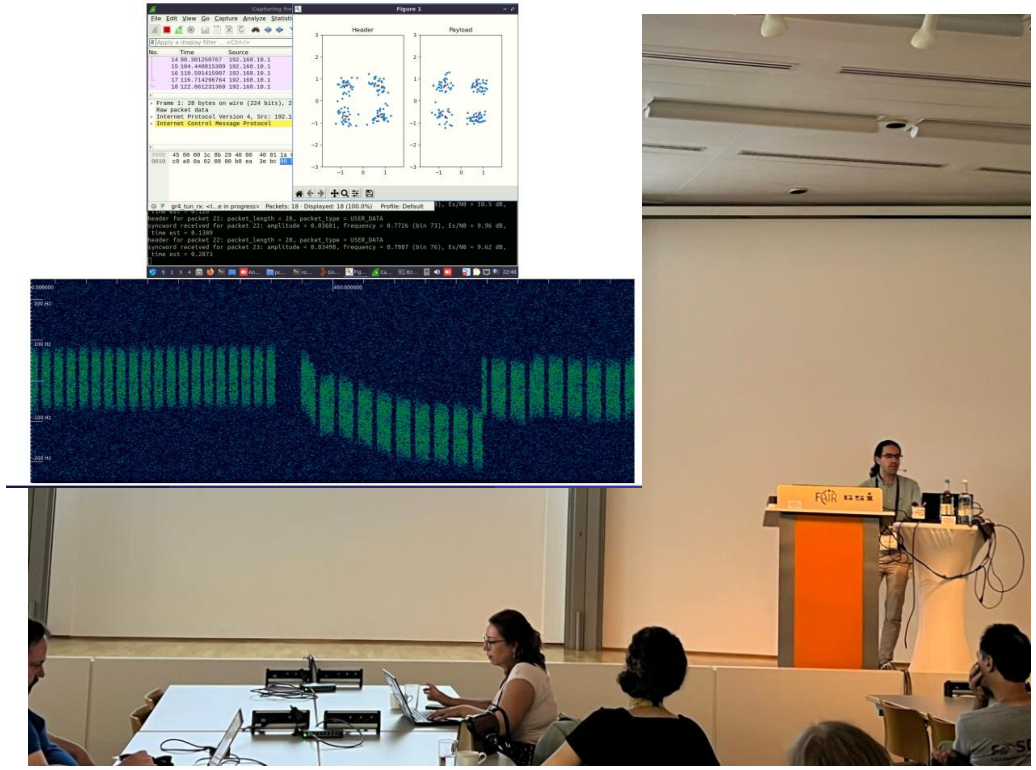
- Benchmark results show potential for significant gains





GR 4.0 Packet Modem

Daniel Estevez – Full packet modem implementation
https://github.com/daniestevez/gr4-packet-modem



Peraton Labs' Technical Capabilities Summary

- **Majority of staff located in multiple sites in NJ, MD and VA, including:**
  - Basking Ridge, NJ
  - Red Bank, NJ
  - Aberdeen, MD
  - Silver Spring, MD
  - Bedford, NH
  - Fort Belvoir, VA
  - W. Lafayette, IN
- **Markets served:**
  - Defense & intel
  - Civilian agencies
  - Utilities
  - Transportation
  - Life sciences

Cyber	Electronic Warfare	Machine Learning/AI	Mobility & Wireless Systems	Networks and Operations	Sensors & Sensor Integration	Optics, Photonics & Quantum
Cyber defense and cloud security	EO/IR/RF technology	Machine learning techniques	High performance comms	Network control and services management	Sensor/laser instrumentation	Optics and optical networking
Cyber warfare	Attack, protect, and counter measures	Automated target recognition	Signal processing applications	Network architecture and protocols design	Spectrum sensing and management	Photonics system design and integration
Critical infrastructure protection	Threat detection	Adversarial machine learning	Wireless network management and security	Software defined networks	Systems architecture and sensor integration	Applications of advanced laser based technologies
Vulnerability and risk assessment	Counter IED/UAS	Autonomy	5G	Network virtualization	Controls and automation	Quantum comms and computing