Information Fusion with Quantized Uncertainty for Heterogeneous Multimodal Data

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PPPL Princeton Plasma Physics Laboratory
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UH ETI Tasks

- TA1.1. Machine learning. Train, test, and evaluate for selected signals of interests.
- TA1.2. Data Fusion. Integrate smartphone multisensory data at unit and collective scales.
- TA1.5. Commercial Ad Hoc Networks.
- TA2.3. Side channel reconstruction.
- TA3.2. Quantify SWAP(C) smartphone/single-board configurations for mission-specific data collection.
- Laboratory Outreach Director for Technology.

Laboratory Recruitment

- **Wednesday, 7 October 2020, 2000-2130 GMT** (1600-1730 EDT)
- **Gatherly Platform Link:**

http://2020etiworkshop.gatherly.io

Lab Collaborators: Signature Types

- David Chichester (INL): Transients, Sweeps
- Steven Magana-Zook: Data Pipelines
- Keehoon Kim (LLNL): Transients
- Cleat Zeiler (NNSS): Transients, Staging
- MINOS/ORNL: Continuous Wave (CW) Anomalies
- Daniel Bowman (SNL): Various; moving airborne platform
- Diverse noise environments.

Information: Entropy

Article

Quantized Constant-Q Gabor Atoms for Sparse Binary Representations of Cyber-Physical Signatures

- Garcés, M. A. (2020). Entropy, 22, 936; doi:10.3390/e22090936
- Open Access paper
- Gabor-Morlet wavelets minimize time-frequency uncertainty

$$\sigma_t \sigma_\omega = \frac{1}{2}$$

Quantized Gabor Atoms are developed to constrain parametrization of time-frequency representations and their uncertainty.

Quantification Order N

$$\Psi_n(m-m') = \frac{1}{\pi^{1/4}} \frac{1}{\sqrt{\mathcal{s}_n}} exp\left\{-\frac{1}{2}\left[\frac{m-m'}{\mathcal{s}_n}\right]^2\right\} exp\left\{iM_N\left[\frac{m-m'}{\mathcal{s}_n}\right]\right\}$$

$$\mathcal{s}_n = \mathcal{s}_0 2^{\frac{n}{N}} = \frac{M_N}{2\pi} f_s \tau_0 2^{\frac{n}{N}}, \quad M_N = 2\sqrt{ln2}\, Q_N$$

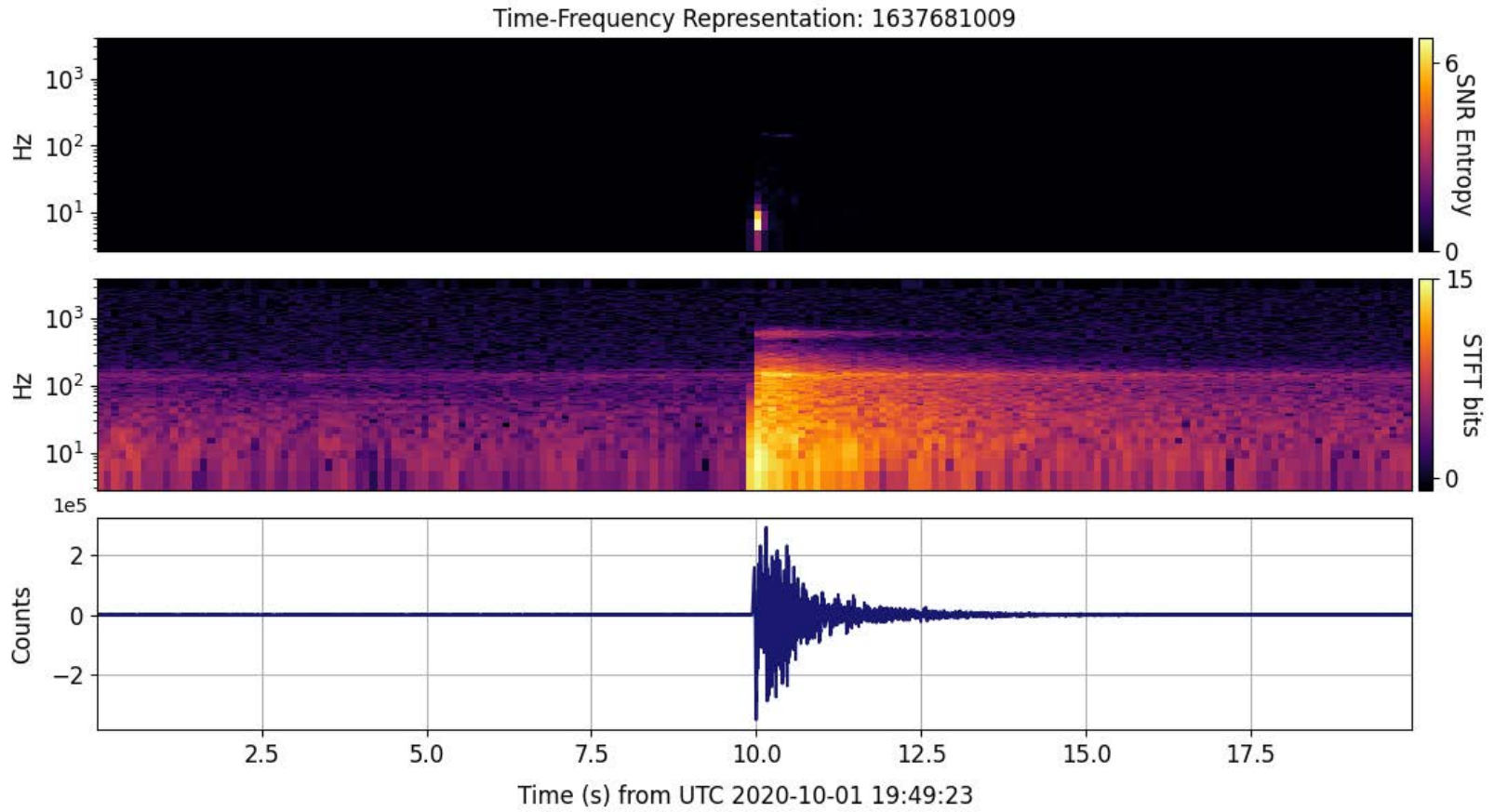
$$Q_N = \left[2^{\frac{1}{2N}} - 2^{-\frac{1}{2N}}\right]^{-1} \approx \sqrt{2}N$$

$$\sigma_{\tau_n} = \frac{1}{\sqrt{2}} \mathcal{s}_n = \frac{1}{\sqrt{2}} \frac{M_N}{2\pi} f_s \tau_n$$

Time-Frequency Representations

Information ~ -log2(proportional energy)

Surprisal probability in bits

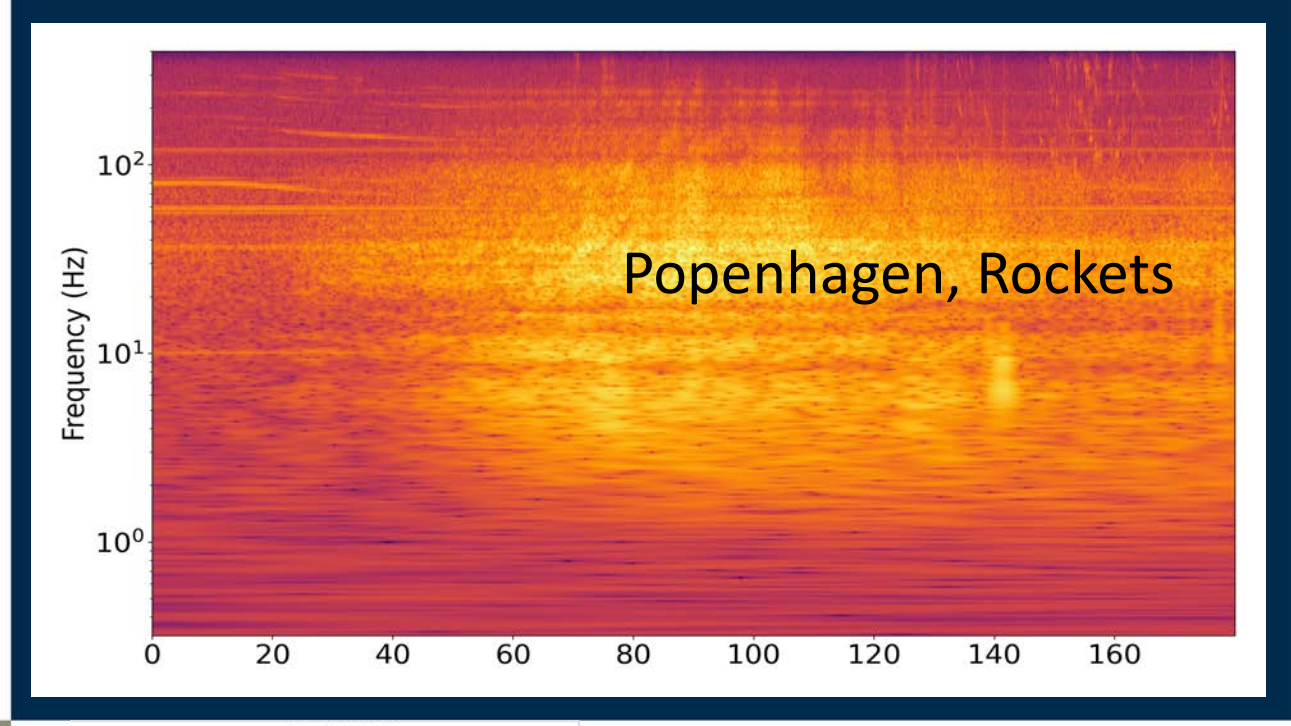


“Happy families are all alike; every unhappy family is unhappy in its own way.” – Leo Tolstoy, Anna Karenina

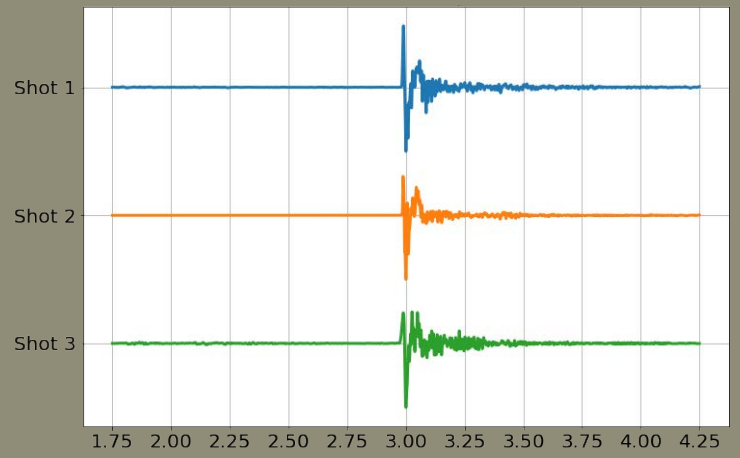
“Like families, tidy datasets are all alike but every messy dataset is messy in its own way.” - Hadley Whickham

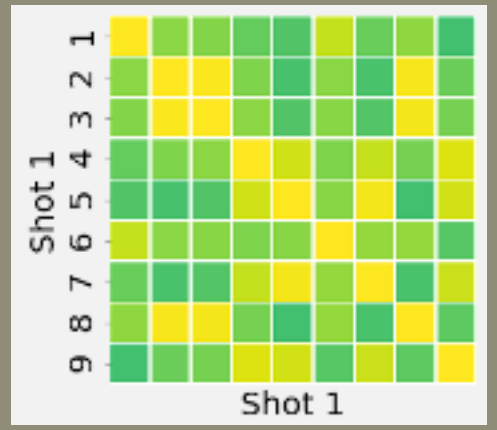
Theory: Implementation

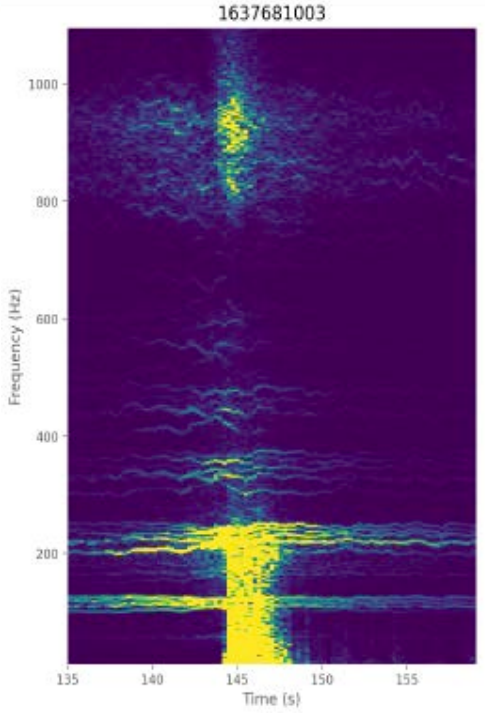
- The boundary between subject matter expertise and machine learning (ML) engineering is migrating towards the edge
- Next generation of scientists has ready access to ML-capable collection platforms



Takazawa et al., HE Blasts







Tobin et al., UAVs

ETI

SWAPC: API M

- Application Programming Interface 1000 (API M) in development
- API M API is platform agnostic
- Low SWAPC: Size, Weight, Power, and Cost
- Various commercial off-the-shelf (COTS) platforms under investigation
- NVIDIA platforms capable of edge training and computing
- Collect power, communication, and processor metrics
- Optimize configurations for mission-specific data collection

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