DEEP LEARNING ON RF DATA

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DOGS ARE NOT SIGNALS

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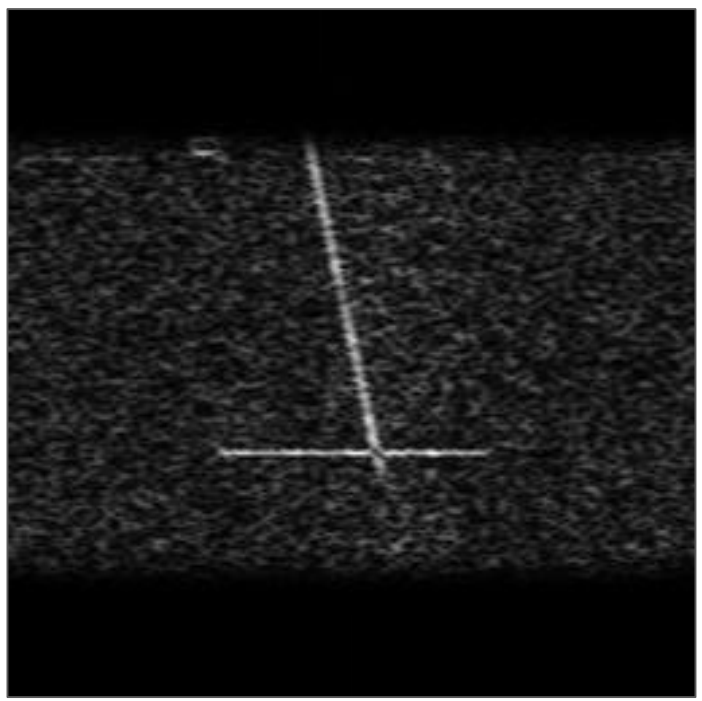


Complex data
Poor SNR and Interference (potentially hard to see features)
Scale (narrow or wideband)

SPECTRAL CONSIDERATIONS

Definitions and Applications

Limited resource: with increasing popularity of wireless communication devices, the wireless spectrum has become congested

Certain frequencies are physically more desirable than others and the rise of spread spectrum communication

Spectral **limitations** include multipath, noise, and interfering signals

Motivation for both **signal identification** and **spectrum awareness**

Classical signal processing approaches are susceptible to false alarms and are often difficult to scale with emerging technologies

MARRIAGE OF DEEP LEARNING AND RF DATA

SIGNAL IDENTIFICATION

Learn features specific to a desired emitter

Fits into many existing RF dataflows

Success in high noise, high interference environments

ANOMALY DETECTION

Facilitates in discovery

Early warning system for defense and commercial applications

Enforce FCC regulations

SCHEDULING

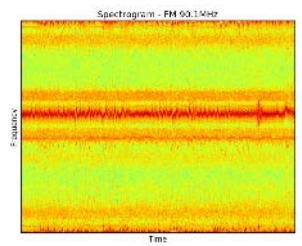
Automatic recognition of free communication channels

Provide a basis for effective signal transmission or reception

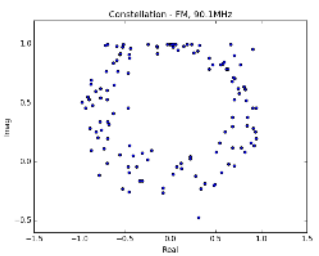
RF DATA DOMAINS

FM Collection – 90.1MHz, 1.8MHz Bandwidth

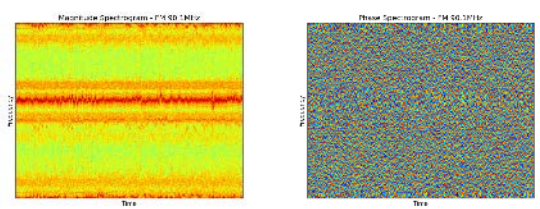
SPECTROGRAM



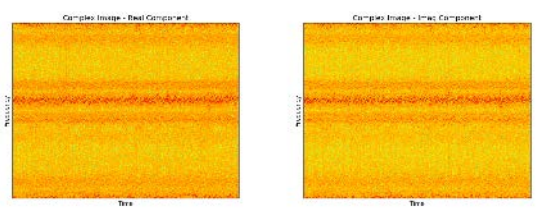
RAW I/Q



MAGNITUDE/PHASE



OTHERS




SPECTROGRAM
DOMAIN

DEMONSTRATION

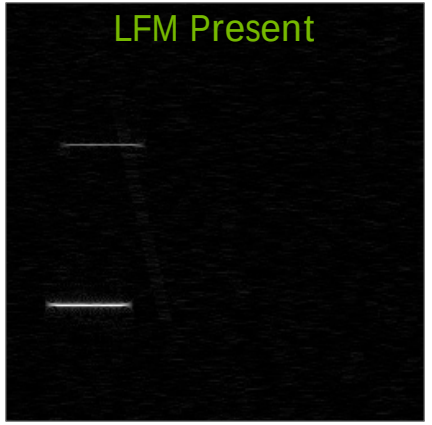
KickView Corporation

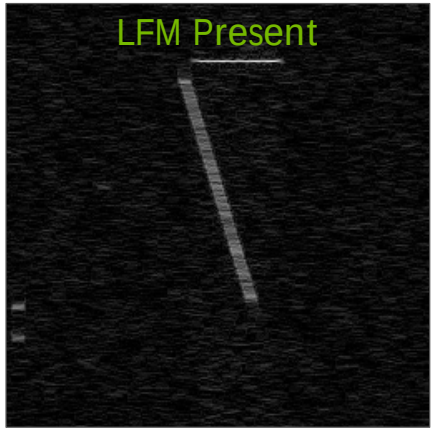
Classification of simulated Linear Frequency Modulation (LFM) signals co-existing with noise and interference

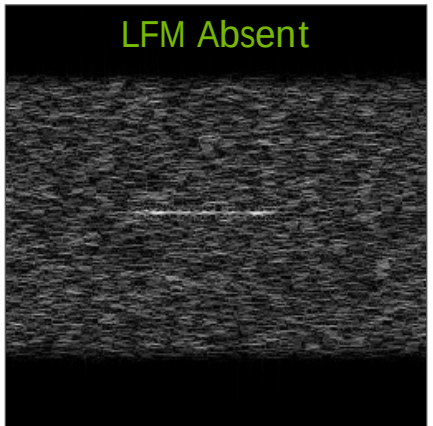
Standard GoogLeNet model trained on a Tesla V100 with 30 epochs and 7,500 labeled images yielded the following confusion matrix on a test set of 2,000 images

Training time was 7 minutes and 43 seconds

	Neg	Pos	Accuracy
Neg	990	10	99.0%
Pos	5	995	99.5%







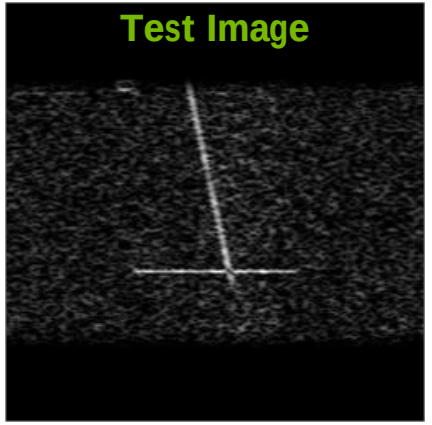
DEMONSTRATION

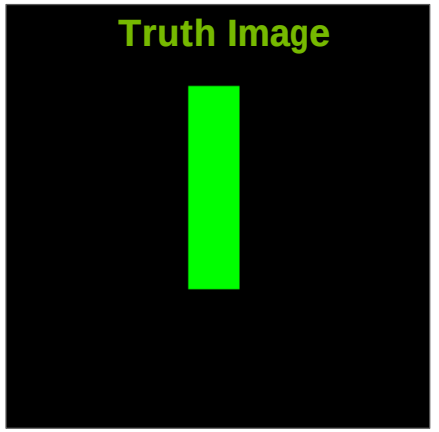
Semantic Segmentation

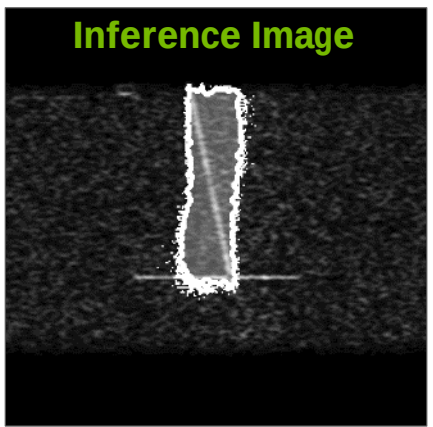
Manually labeled data by creating a boxed mask highlighting relevant signal energy

1000 training images and 100 validation images using a fully convolutional U-Net architecture shows initial promising results

Trained on a V100 with 30 epochs in 20 minutes and 24 seconds








I/Q DOMAIN

I/Q APPROACHES

Overview

Allows deep learning to be applied to the sensor level and can facilitate real time decisions

Preserves phase information which is important in both demodulation and RADAR applications for determining characteristics about the target

Active research on modulation recognition by Tim O'Shea and DeepSig using simulated and OTA data

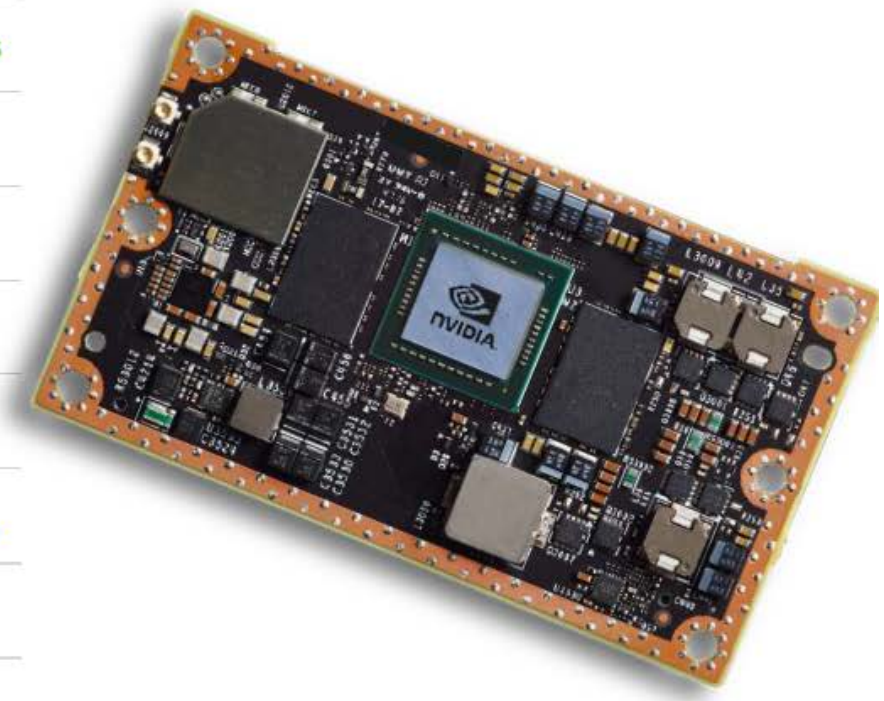
Training occurred with 120,000 synthetic examples using the ResNet architecture and a TitanX GPU (60 seconds/epoch) - 94% accuracy on simulated data and 87% on OTA data

O'Shea et al.: Over the Air Deep Learning Based Radio Signal Classification - https://arxiv.org/pdf/1712.04578.pdf


DEPLOYMENT

EMBEDDED GPU SPECIFICATIONS

	JETSON TX1	JETSON TX2
GPU	Maxwell	Pascal
CPU	64-bit A57 CPUs	64-bit Denver 2 and A57 CPUs
Memory	4 GB 64 bit LPDDR4 25.6 GB/s	8 GB 128 bit LPDDR4 58.4 GB/s
Storage	16 GB eMMC	32 GB eMMC
Wi-Fi/BT	802.11 2x2 ac/BT Ready	802.11 2x2 ac/BT Ready
Video Encode	2160p @ 30	2160p @ 60
Video Decode	2160p @ 60	2160p @ 60 12 bit support for H.265, VP9
Camera	1.4Gpix/s Up to 1.5Gbps per lane	1.4Gpix/s Up to 2.5Gbps per lane
Mechanical	50mm x 87mm 400-pin Compatible Board to Board Connector	



DEEPWAVE

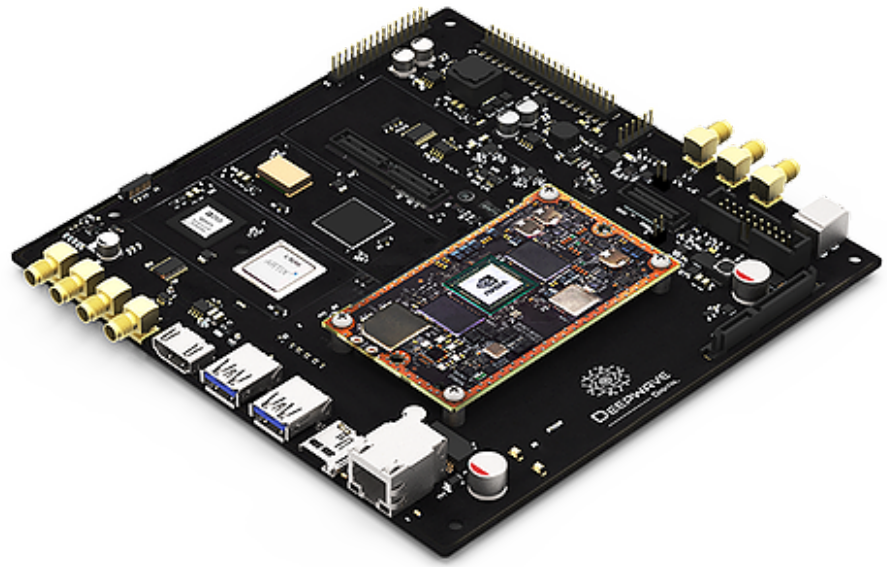
AIR-T Hardware Solution

Software defined radio (SDR) designed for deep learning applications

Placing AI at the edge to process high bandwidth data in real time (> 1GB/s)

Includes FPGA for latency cognizant signal capture

Tegra series embedded GPU




PROGRAMS OF
INTEREST

PROGRAMS OF INTEREST

DARPA RFMLS

Design RF system capable of AI enabled transmit and receive tasks

Transmission: Waveform synthesis

Receive: Feature learning, Attention and Saliency, Autonomous RF Control

https://www.darpa.mil/news-events/2017-08-11a

ARMY SIGNALS CHALLENGE

Open competition with the goal of advancing blind signal classification and characterization

Data consists of 24 different modulation schemes at various SNRs

https://sites.mitre.org/armychallenge/

DARPA SC2

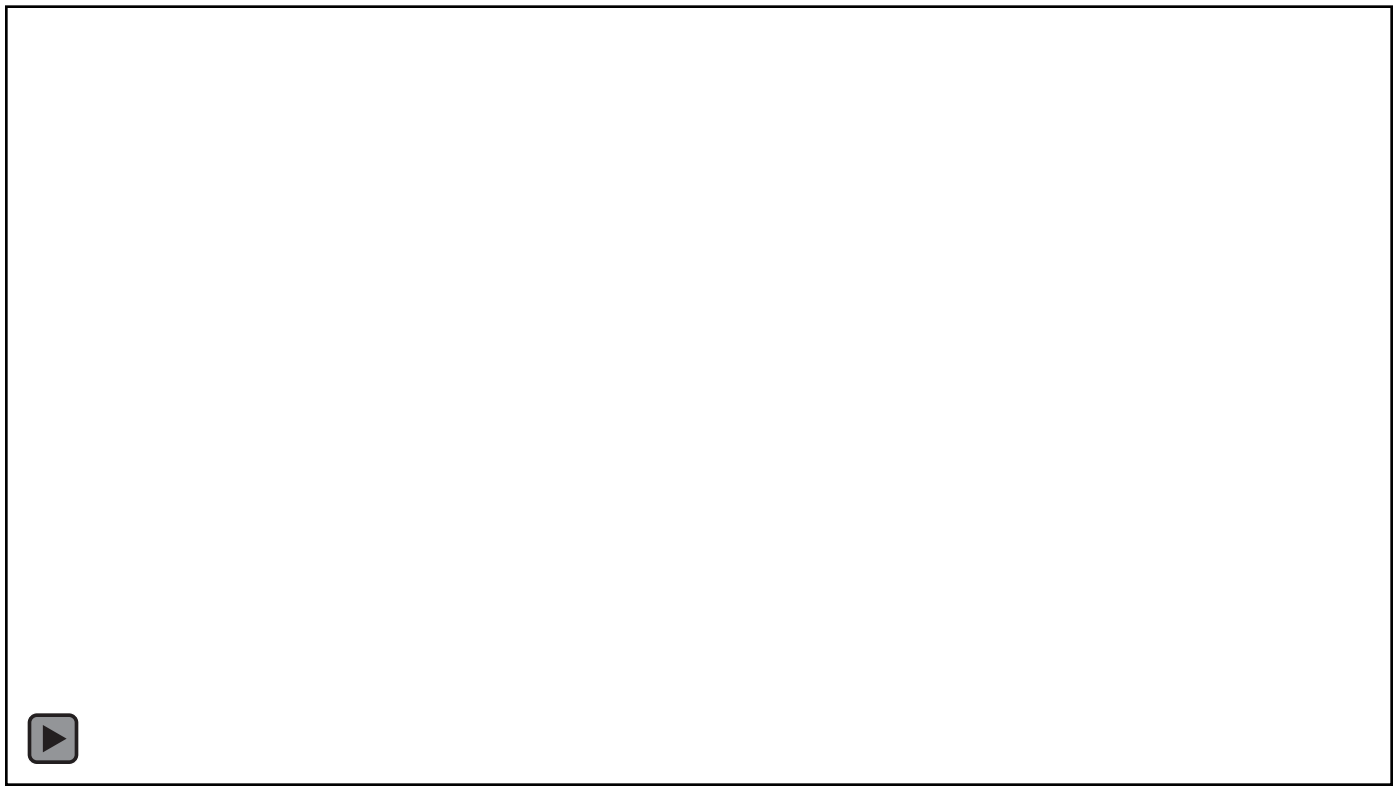
Development and design of Collaborative Intelligent Radio Networks (CIRNs) to facilitate spectrum sharing through collaborative spectrum optimization

https://spectrumcollaborationchallenge.com/


MULTI-INT FUSION

RF POSE – MIT CSAIL LAB

Human Pose Estimation Through Walls with WiFi Exploitation

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