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Near Sensor Image Denoising with Deep Learning: Review, Perspectives, and Application to Information System Security

Florian LEMARCHAND[†], Erwan NOGUES [†‡] and Maxime PELCAT[†§]

[†] **IETR/INSA, Rennes, France**

[‡] DGA-MI, Bruz, France

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Summary:

RESSI – May 16th 2019

Introduction

Context:

- PhD Title : Recognition of Images and Intercepted Signals using Embedded Artificial Intelligence
- Pôle d'Excellence Cyber (PEC) PhD Grant
- Partnership between DGA-MI and IETR VAADER
- DGA-MI and DGA-IA developed ToxicIA --> Proof Of Concept (POC) on using machine learning to enhance the interpretation of compromising emanations
- POC has ended and is transfered to VAADER team for perspective further enhancement
- This PhD has ToxicIA as a case study

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Compromising Emanations Detection

Target System With Video Display

Display signal can be digital (e.g. DVI, DP, HDMI) or analog (e.g. VGA).

≈ 10 m

Compromising Emanations

Current Interception System to be Embedded

Antenna — Software-Defined Radio — Laptop

Bilog — Ettus X310 100MHz — Intel Xeon W-2125 Nvidia GTX1080 Ti

Interpretation Pipeline: Case Study of Character Retrieval

1/ Raster

EM Signal → Signal Processing → Noisy Image ≠ Original Image

2/ Denoising and Retrieval

Method 1: Denoising + OCR

+ Adjustable Interpretation
− Poor Retrieval Performances

Denoising: Autoencoder, BM3D

Optical Character Recognition: Tesseract

Method2: Mask R-CNN [5]

+ Good Retrieval Performances
+ Character Masks Available
− Heavy Computations
− Dedicated Training

Segmentation & Classification:

Retrieved characters & their positions (+ masks)

3/ Further Processing

Key Word Recognition

Alert found: confidential

Alarm Raising for Human Action

System Shutdown

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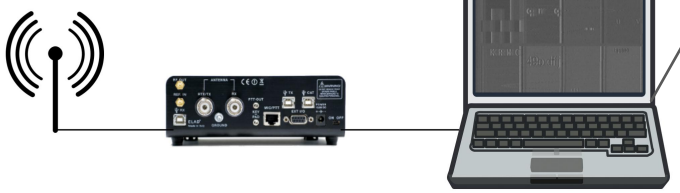

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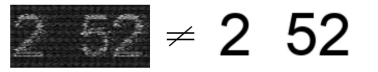

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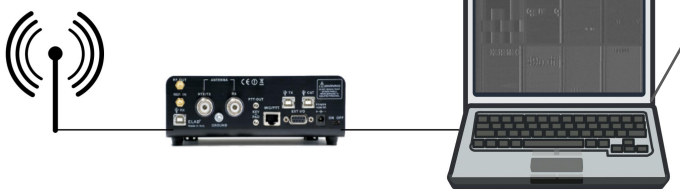

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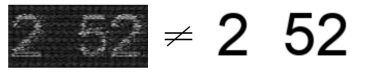

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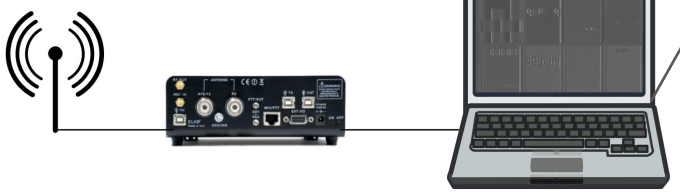

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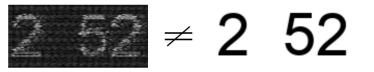

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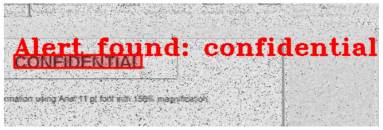

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Statistical Image Denoising

Noisy Sample

Denoising Methods

Denoised Sample

Non-Statistical

\+ Low Computation
\+ No need for training dataset
− Dedicated to a noise model

e.g. : Filters (Median, Mean, ...)
Block-Matching 3D (BM3D)
Transform Domain (FFT)

Statistical

\+ Support several noise models
\+ High SNR improvements
− Heavy computations

e.g. : Stacked/Sparse Auto-Encoders
Generative Adversarial Networks
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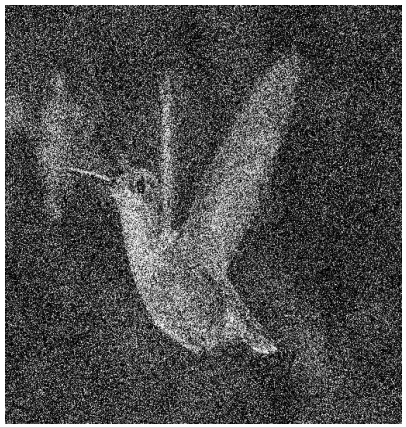

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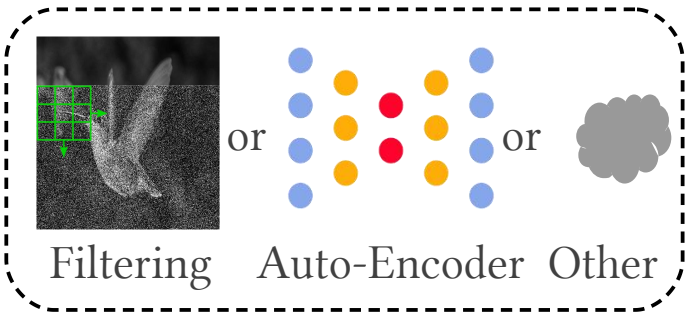

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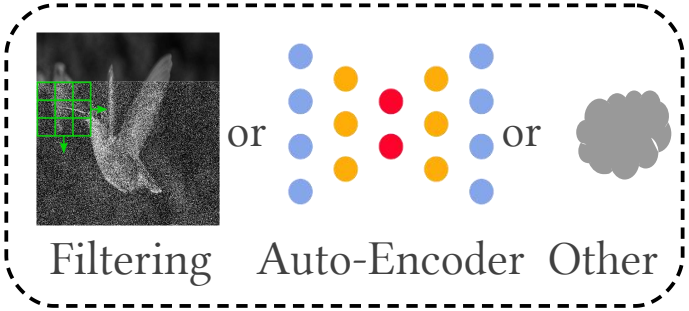

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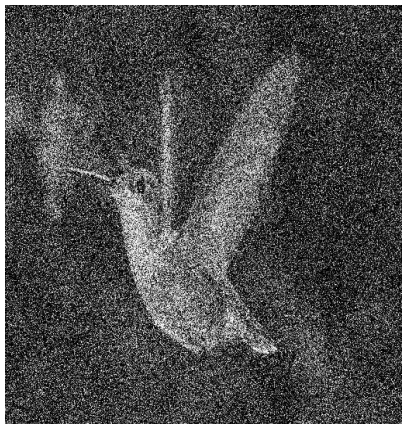

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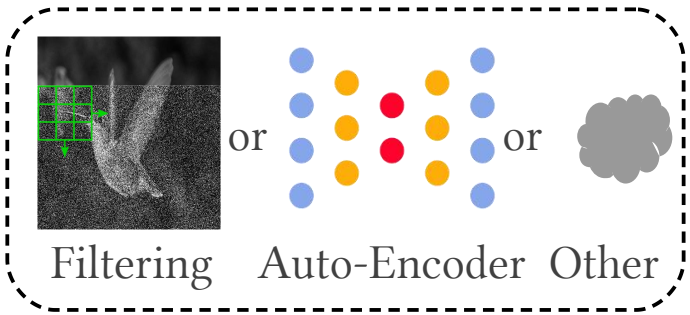

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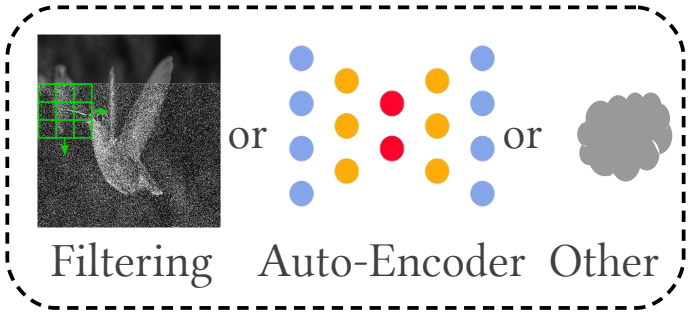

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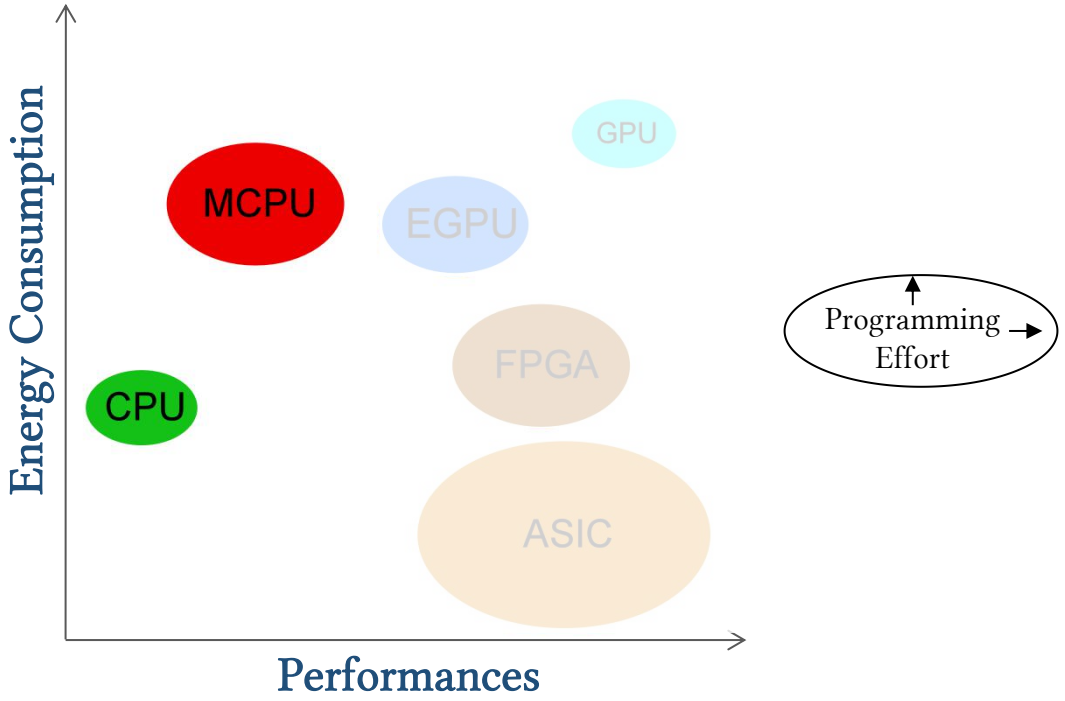
Near Sensor Platforms for Statistical Denoising

- **Single, Multi, Many-core CPUs :** New instructions set made especially for Deep Neural Networks (DNN) ⟶ Intel, ARM, Kalray
- **FPGAs :** High parallelism and good energy efficiency ⟶ Intel (ex-Altera), Xilinx
- **ASICs :** Application specific hardware highly efficient
- **Embedded GPUs :** Low power consumption and good performances ⟶ Nvidia, Coral, Intel



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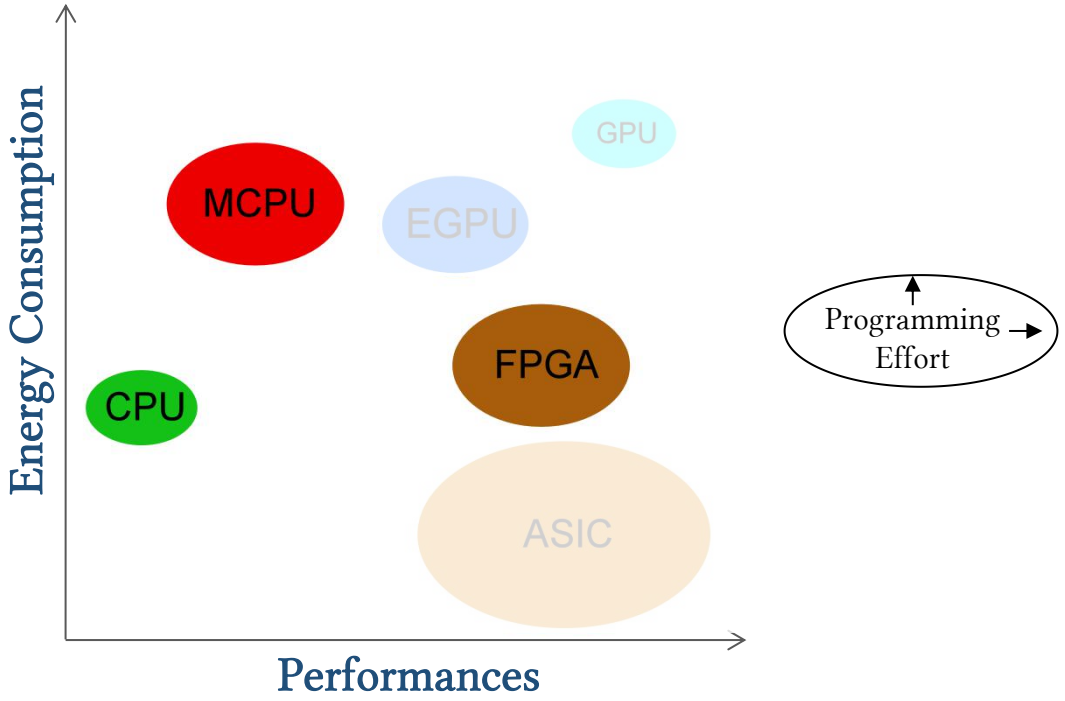

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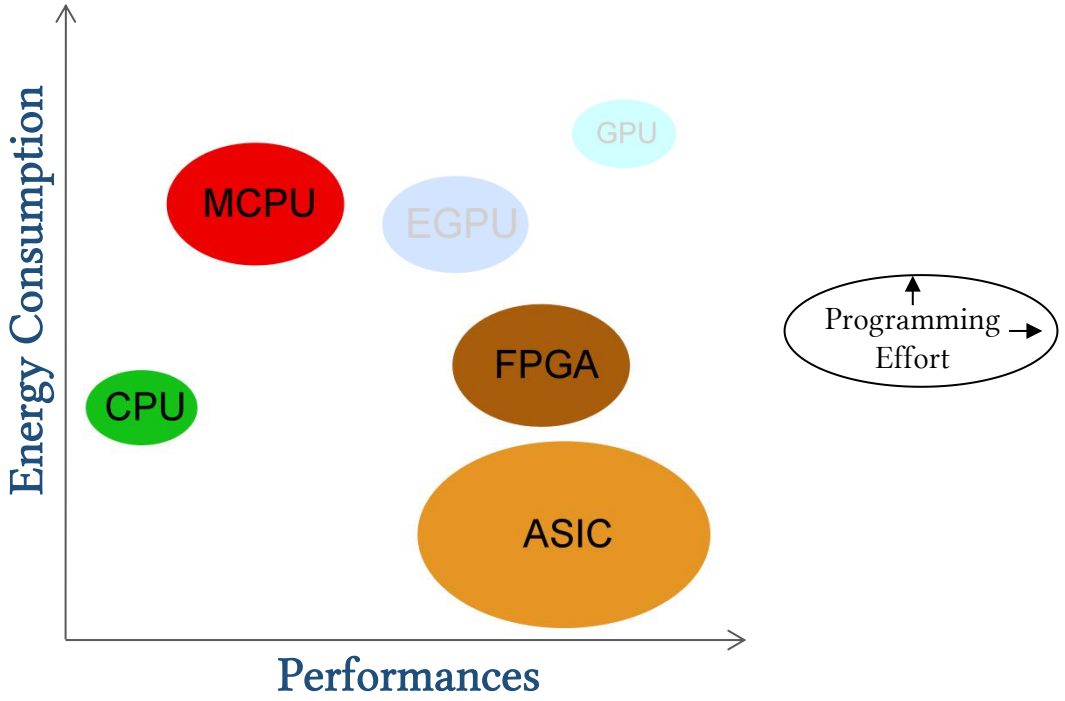

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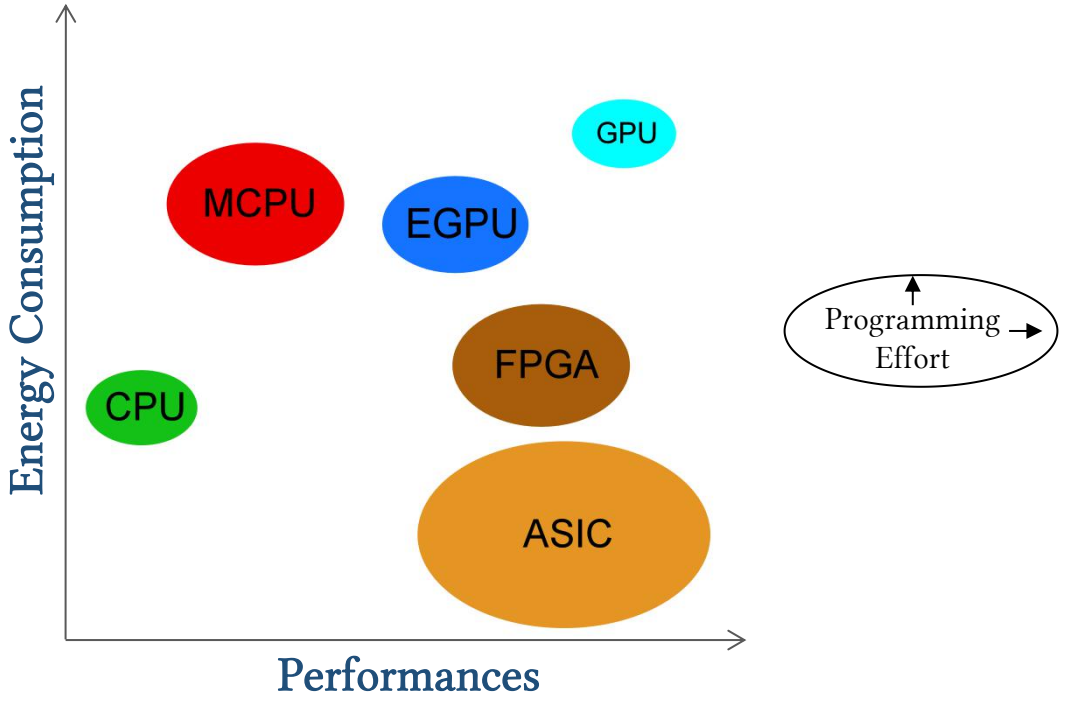


Perspectives for ToxicIA

Network Reduction

- Connection pruning
- Weight quantization/sharing
- Huffman coding

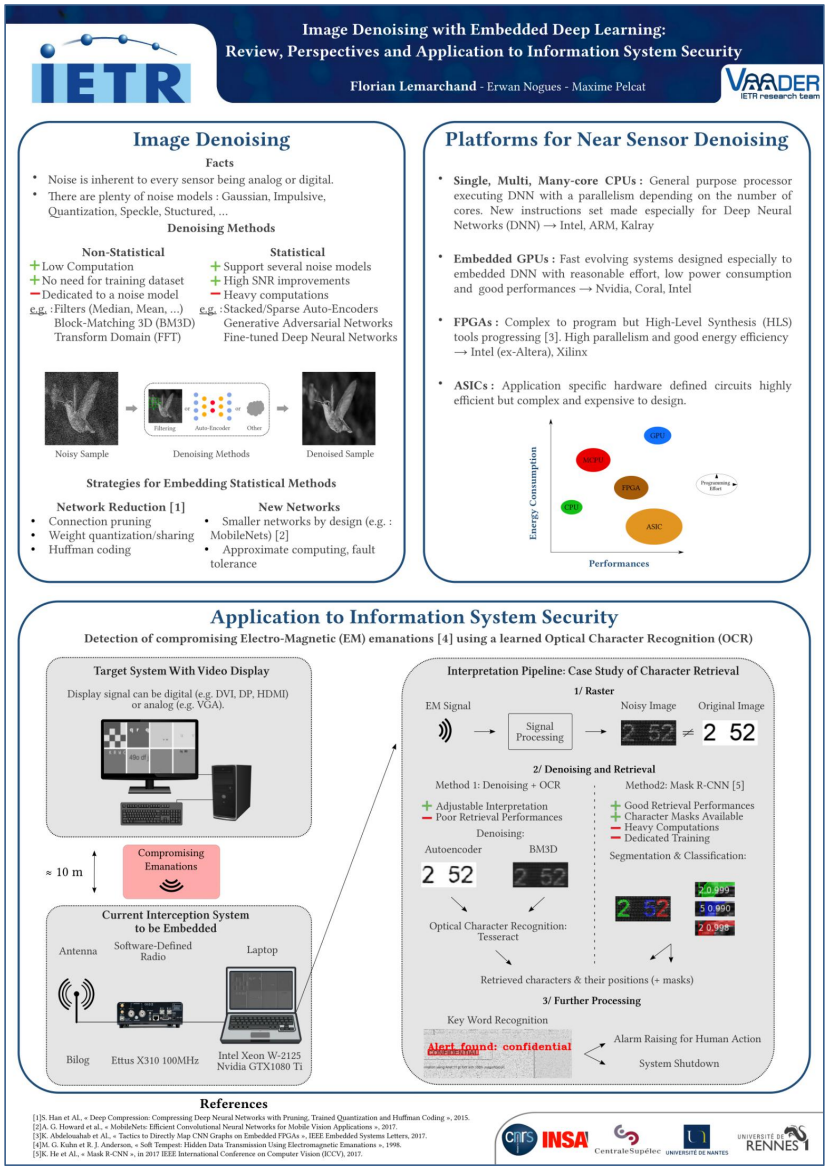
New Networks

- Smaller networks by design (e.g. : MobileNets)
- Approximate computing, fault tolerance

Training Phase Enhancement

- Better choice of training samples
- Data Augmentation
- Artificial sample generation

Questions & Discussions



Thank you for your attention!

For questions --> Poster Session at 18:15 p.m.

Contact :

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