SaTC: Core: Medium: Protecting Confidentiality and Integrity of Deep Neural Networks against Side-channel and Fault Attacks

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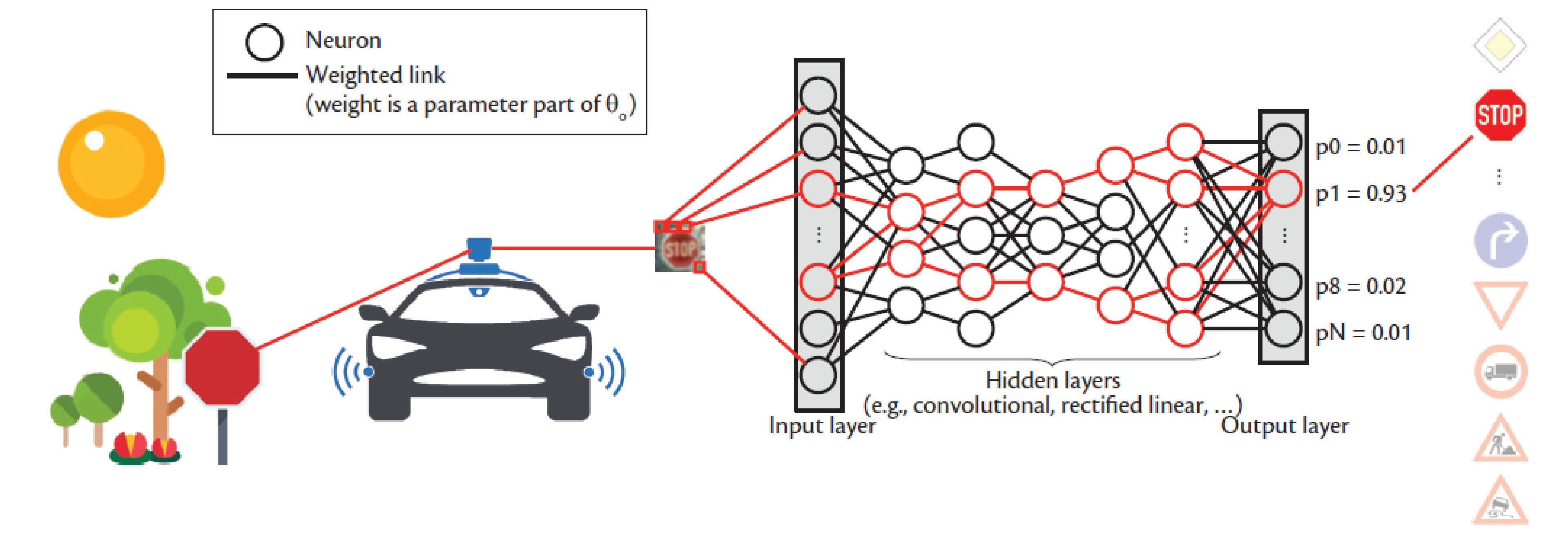

Medical Image Analysis with Deep Learning

Challenge:

- Serious security implication of DNNs
  - Integrity/availability of DNN execution will affect safety, access control, and trust of DNN-supported systems and services
  - Data is valuable and therefore trained DNN model becomes IP, privacy issue too
  - Existing DNN security does not address side-channel leakage and fault injections
- Diverse models, platforms, optimizations, and applications for DNNs

Proposed Solution: ensure secure DNN execution

- *SpyNet*: recovering DNN structure and parameters on diverse platforms
- *DisruptNet*: manipulate DNN operations via hardware and software fault injections
- *SecureNet*: network obfuscation against side-channel attacks, detection of integrity violation of DNNs, and hardening techniques for fault resistance

Scientific Impact:

- Investigate a new attack surface of DNN inference
- Systematically protect confidentiality and integrity of DNNs
- Deepen understanding of inherent information leakage and fault tolerance of DNN models
- Incorporate formal methods for integrity violation detection and prevention

	Model Information	HW Implementation	SW Implementation
Structure characteristics	# layers	power SPA	
		memory access	μarchitecture (I$, PMC)
	type of layer, activation	power SPA, timing	
	connection/ layers		
Hyperparameters	# neurons in FC	power SPA	μarchitecture (I$, PMC)
	# of kernels in CONV	power SPA, memory access	I$, D$, PMC, constraints
	size of kernel in CONV/POOL	memory access	I$, D$, PMC, constraints
Parameters	weights in FC	power DPA, bus snoop	FP
	kernel values in CONV	power DPA, bus snoop	timing μarchitecture, FP

		HW implementation		SW implementation	
		Resource	Fault Type	Resource/Stage	Fault Type
Computation		datapath PE	output: stuck-at, random	instruction execution	skip,control/data flow
		control logic	control flow		
Data	reuse	buffer	set/reset, random	DRAM	set/reset, random, flip (rowhammer)
	temporary	registers	set/reset, random (DVFS)	registers	set/reset, random (DVFS)

Broader Impact:

- Facilitate wide adoption of DNN in security-critical applications
- Advance the state-of-the-art DNN implementations (edge and cloud), heterogeneous systems, hardware security, formal methods and verification
- Interdisciplinary research

Education and Outreach:

- Integrate research with education – hardware security, DL implementation, engineering reliable software
- Engage underrepresented students, undergraduates, high-school students in research
- Technology transfer with company partners through a new NSF IUCRC center

Assessment:

- 9 undergraduates from partner community colleges and HBCUs
- 6 high school seniors from URM groups through NU Young Scholars Program
- Professional from Programs and Operations in the Center of STEM Education to assist outreach and assessment

The 4th NSF Secure and Trustworthy Cyberspace Principal Investigator Meeting (2019 SaTC PI Meeting)
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