Machine Learning on the Edge
With a focus on Security
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Machine Learning at the Edge framework that enables learning capabilities on small footprint Micro-controllers

ARM M4 – M7 series microcontrollers
STM F4 - F7 series microcontrollers
Characteristics of the system built

**Extremely fast**
89ms for processing 1s sound

**Low Power**
Consumption of ~ 89 µA/MH

**Extremely Small**
Model size of just 3.6KB

**Highly Accurate**
Accuracy of around 91.2%

On an F4 STM32 Microcontroller with 180 MHz, 256 KB ROM, 128 KB SRAM
Inferencing Engine at the Edge

An Inferencing Engine at the Edge for Prediction and Quick Action
Semantic Nodes

Enables Data Collection at scale enabling continuously improving domain aware edge nodes.
Ethical & Private by Design

Provides an ethics framework where training data and models cannot be misused by customer organizations.
Plenty of the brain that we do not know yet.

Borrowed principles from Evolutionary theory and from theories of Behavioural Science

**Low-level Functions are well understood**
- Sensory functions (sight, hearing, smell, taste, touch)
- Motor functions (object grasping)
- Sensorimotor functions (obstacle avoidance)

**High-level Functions are Partially understood**
- Perception
- Situation awareness
- Decision making under uncertainty
- Learning
- Adaptation

**Group Low & High level Functions**

**Low level functions**
- Cooperative data gathering
- Information Exchange
- Cooperative Manipulation

**High-level Functions**
- Shared situation awareness
- Consensus finding
- Cooperative decision making
- Multiagent learning
Lamarckian Inheritance

From Evolutionary Theory

As an organism develops:
• It acquires many individual characters due to its particular history of accidents, interactions, diseases and muscular exercises.

Credit: Lamarck and Darwin

As a particular ML model develops:
• Learning from nodes are inherited to members of that group/organisation only.
• Inheritance Management System
Flow

From Behavioural Science

- A state of complete immersion in an activity.

Direct Memory Access
- Instructs the microcontroller to turn down any ISR
Focus on System 1 Use Cases

From Behavioural Science

SYSTEM 1
Intuitive & Instinctive

95%

ML on the Edge
Limited Computation

Associative
Automatic
Unconscious
Quick

SYSTEM 2
Detail oriented

5%

Regular ML
ML on the Cloud
Unlimited Computation

Effortful
Slow
Complex
Deliberate

Credit: Daniel Kanheman, Nobel Prize for Economics, 2002
Law of least effort

From Behavioural Science

- In the economy of action, effort is a cost
- Switching from one task to another is effortful, especially under time pressure.

- Practise and effort in only one set of tasks ensures extreme low power consumption
Controlled Mutation

From Evolutionary Theory

- Mutations happen when there is a change – small or big, in the code
- Experiences can bring about a mutation

- Encode a sequence in each group for ensuring group level privacy and integrity
- Tools for ethical and dataset preparation
Use in SDGs

- Understanding sound anomalies
- Inferring temperature changes and notifying threshold variation in advance
- Inferring voltage patterns and alerting on potential productivity issues
Use in SDGs

- Enable access for the differently abled
- Provide usage for the illiterate
• Infer hyperlocal environment pollution in advance
• Techniques for Dataset preparation
**Use in SDGs**

- Service delivery using voice
- Feedback and engagement mechanisms
Summary: Need for ML at the Edge

- Lightly connected or disconnected models
  - Prevent Communication Interception
  - Prevent Phishing and Leaks
  - Prevent Data Theft

- Control mutation from going rogue
- Ethical Methods for Dataset preparation
- Semantic Inheritance
Thank You
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