Machine Learning on the Edge

With a focus on Security

Bipin@Gaia.in

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

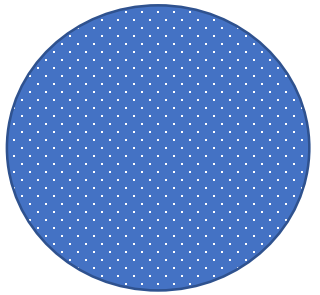
Characteristics of the system built

Extremely fast
89ms for processing 1s sound

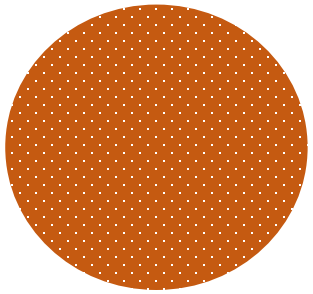
Low Power
Consumption of ~ 89 µA/MH

Extremely Small
Model size of just 3.6KB

Highly Accurate
Accuracy of around 91.2%



1 Million X

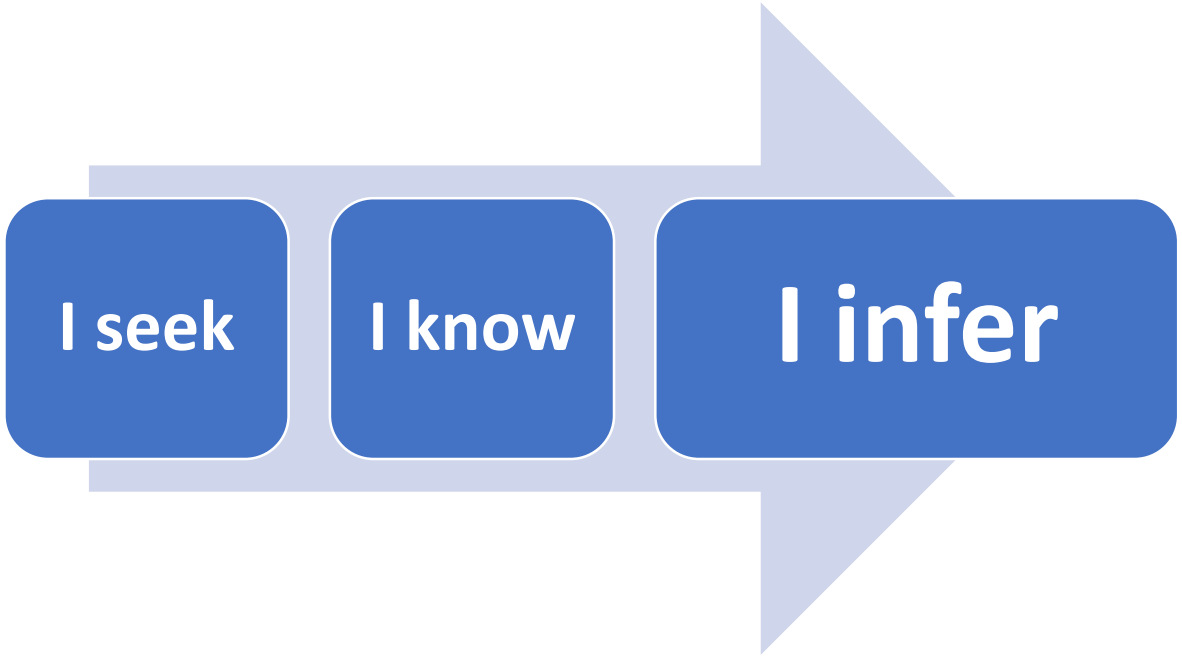


1 Thousand X

On an F4 STM32 Microcontroller with
180 MHz, 256 KB ROM, 128 KB SRAM

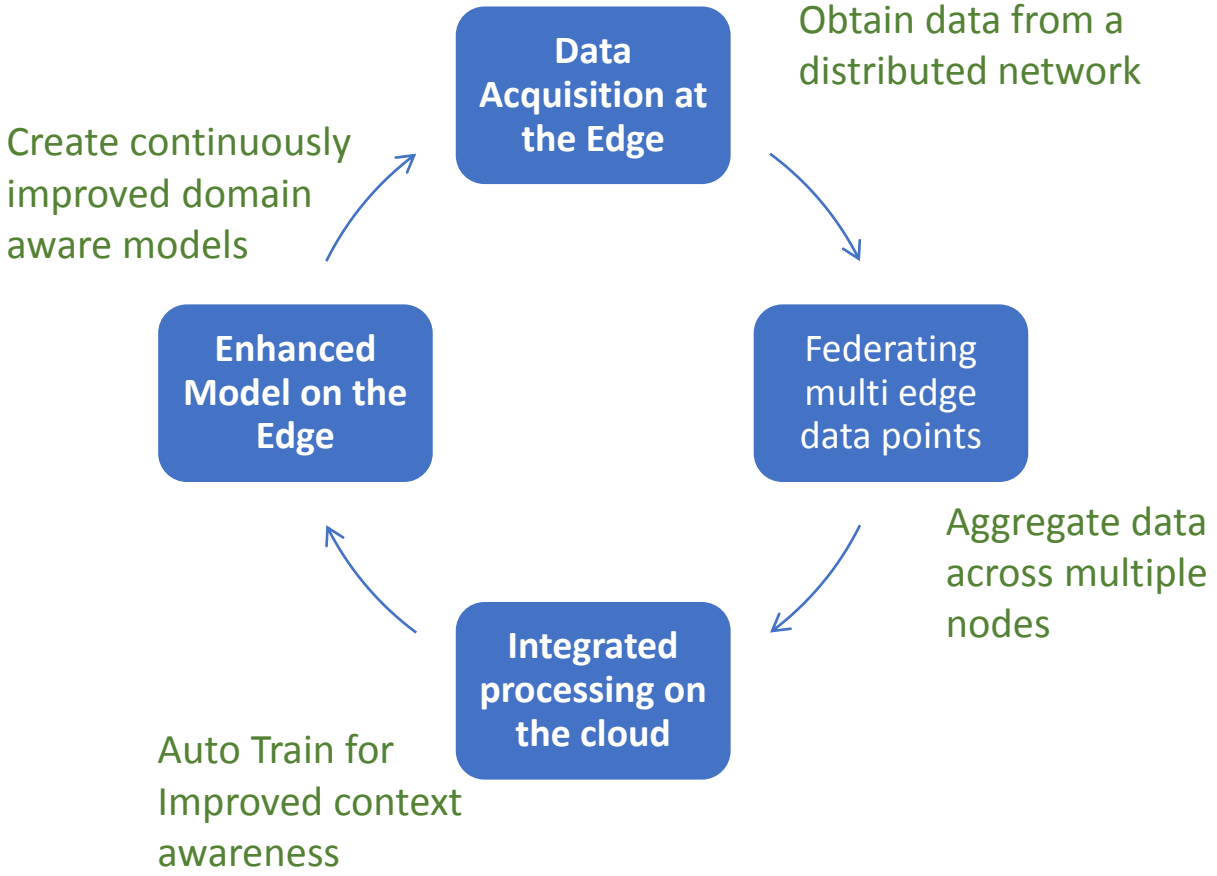
Inferencing Engine at the Edge

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

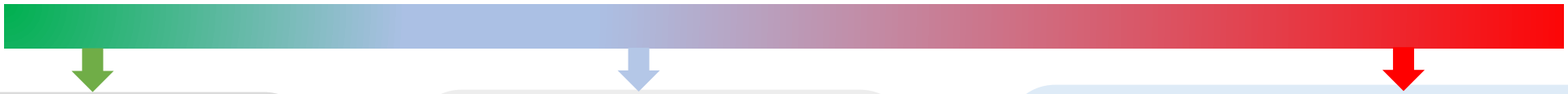


Ethical & Private by Design

Provides an ethics framework where training data and models cannot by misused by customer organizations

Borrowed principles from Evolutionary theory and from theories of Behavioural Science

Plenty of the brain that we do not know yet.



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

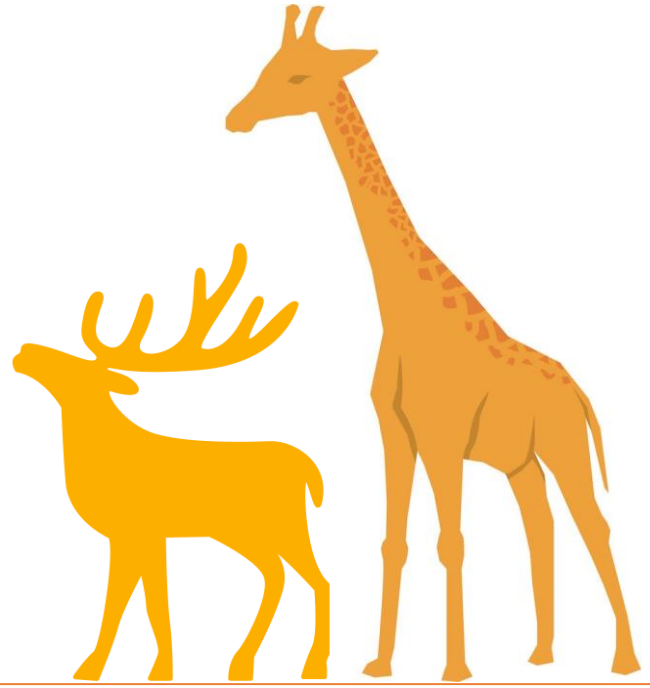
- Cooperative data gathering
- Information Exchange
- Cooperative Manipulation

High-level Functions

- Shared situation awareness
- Consensus finding
- Cooperative decision making
- Multiagent learning

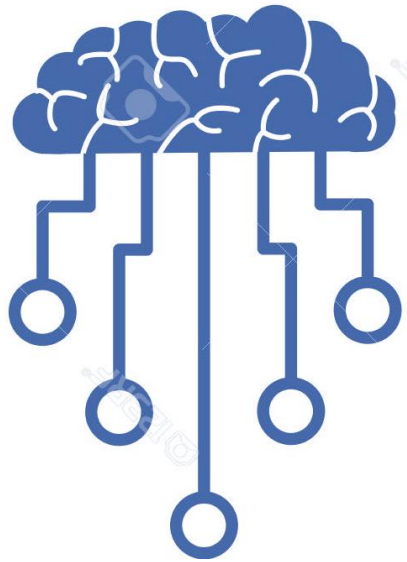
Lamarckian Inheritance

From Evolutionary Theory



As an organism develops:

- It acquires many individual characters due to its particular history of accidents, interactions diseases and muscular exercises.



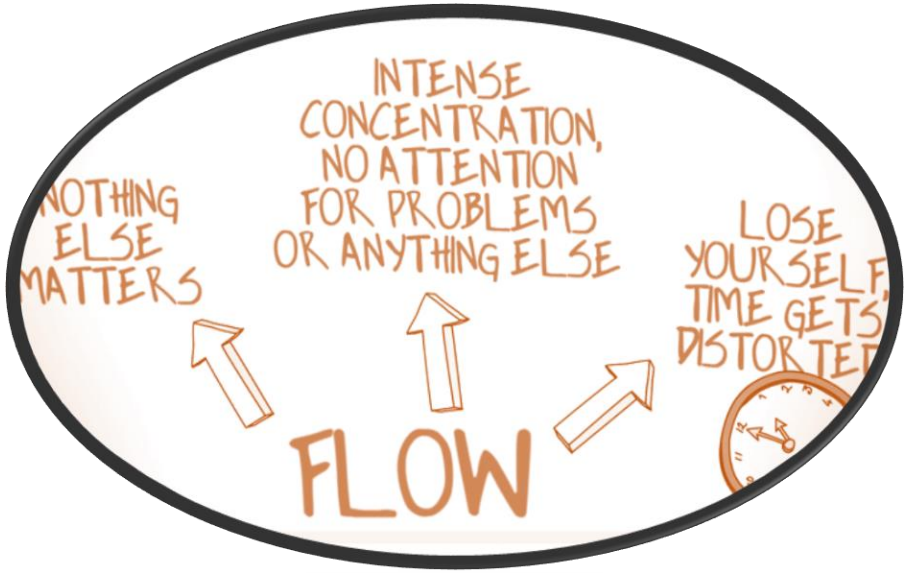
As a particular ML model develops:

- Learning from nodes are inherited to members of that group/organisation only.
- Inheritance Management System

Credit: Lamarck and Darwin

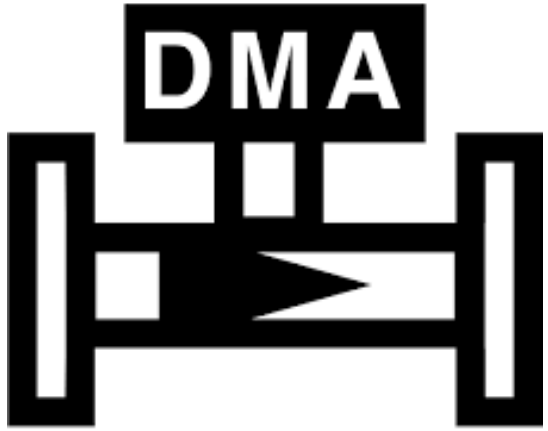
Flow

From Behavioural Science



- A state of complete immersion in an activity.

Credit: Mihaly Csikszentmihalyi



- 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%

Associative
Automatic
Unconscious
Quick

SYSTEM 2

Detail oriented

5%

Effortful
Slow
Complex
Deliberate

ML on the Edge

Limited Computation

Regular ML
ML on the Cloud

Unlimited Computation

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

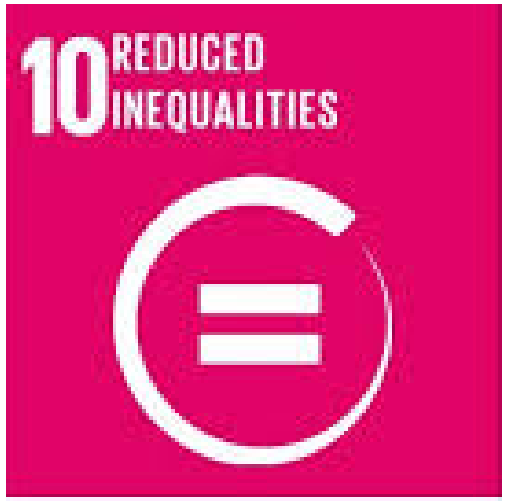
- Mutations happen when there is a change – small or big, in the code
- Experiences can bring about a mutation

- 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

Use in SDGs

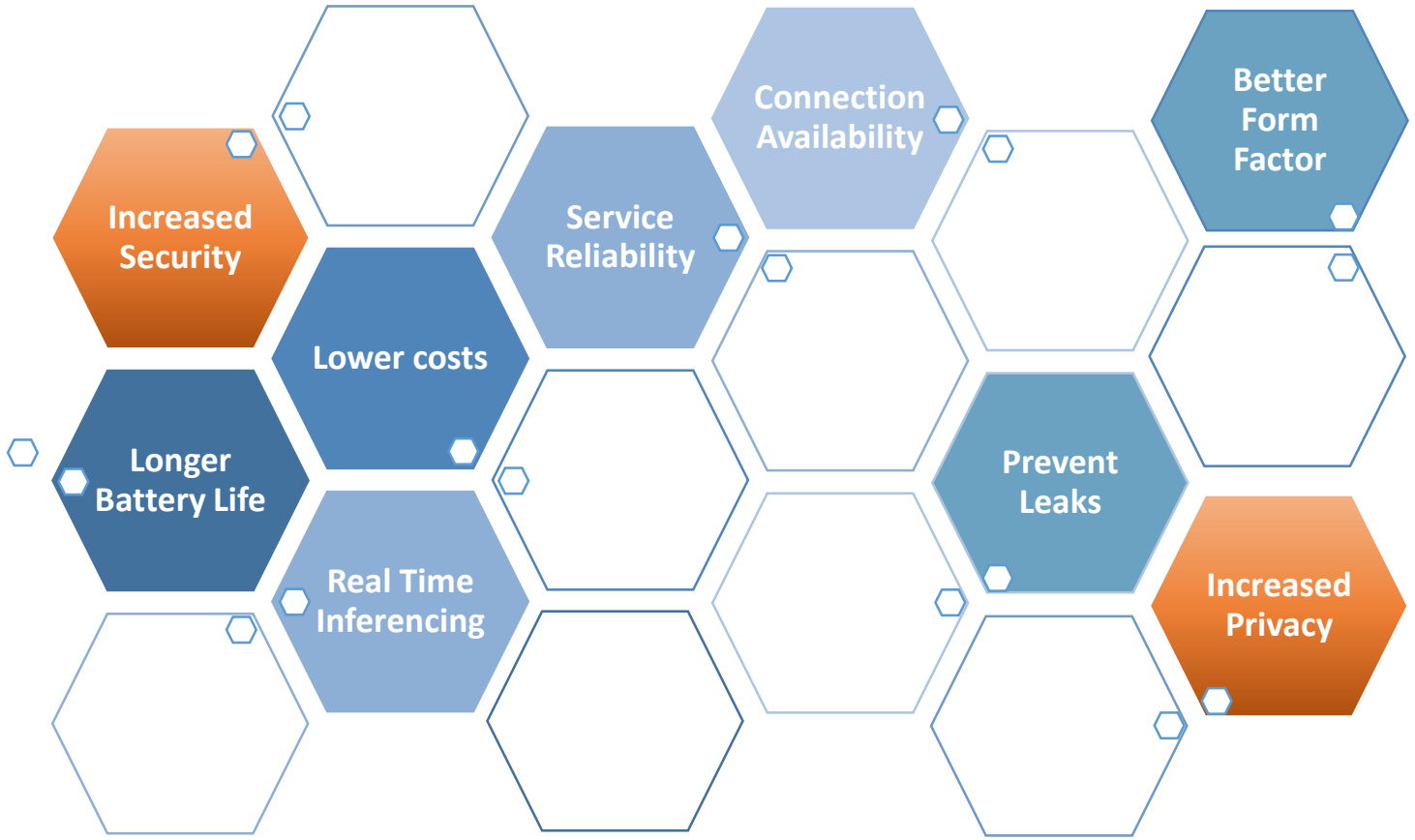
- Infer hyperlocal environment pollution in advance
- Techniques for Dataset preparation

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

www.gaia.in

Bipin@gaia.in