Application Note

SIGNAL MONITORING AND NOVELTY DETECTION WITH NEUROMEM

THE APPLICATION

The essence of predictive maintenance is to detect drifts before damage or fault occurs and NeuroMem is the only neuromorphic chip capable of autonomous "Novelty Detection" and recording in a footprint of a few square millimeter and for a power consumption of mWatts.

pressure, temperature

EEG, EKG, biosensors

vibration, audio

We can envision putting a chipset NeuroMem+eFPGA into each ball bearing of an helicopter to record novel vibrations during a flight and help determine the parts which should be changed at the next maintenance; Predict when the heavy lifting cables of a crane need to be replaced due to actual history rather than a timetable; Monitor the pressure of a sealing robot and signal the operator when it becomes inconsistent; or insert the chipset in a heart monitoring device, or simply a wearable, to record novel heart beat and send them to the physician.

THE SOLUTION

The method to deploy anomaly detection with a NeuroMem network is the same regardless of the type of input stimuli to monitor.

The minimum hardware is composed of an FPGA and a NeuroMem network to be sized depending on the variability of the stimuli to monitor. The network can be composed of a single chip or multiple chips and the device can have provision for an expansion of NeuroMem chips. Such expansion will be seamless and does not require any revision of the state machine executed by the FPGA.

PRELIMINARY LEANING OF A “NORMAL” KNOWLEDGE

For a given stimuli to monitor, the first step is to determine which signature(s) to extract and learn to model what is the domain of variability of a normal stimulus. Obviously in real-life applications, such variability is non-linear, and this is where a NeuroMem network will be extremely advantageous with its Radial Basis Function modeling capabilities.

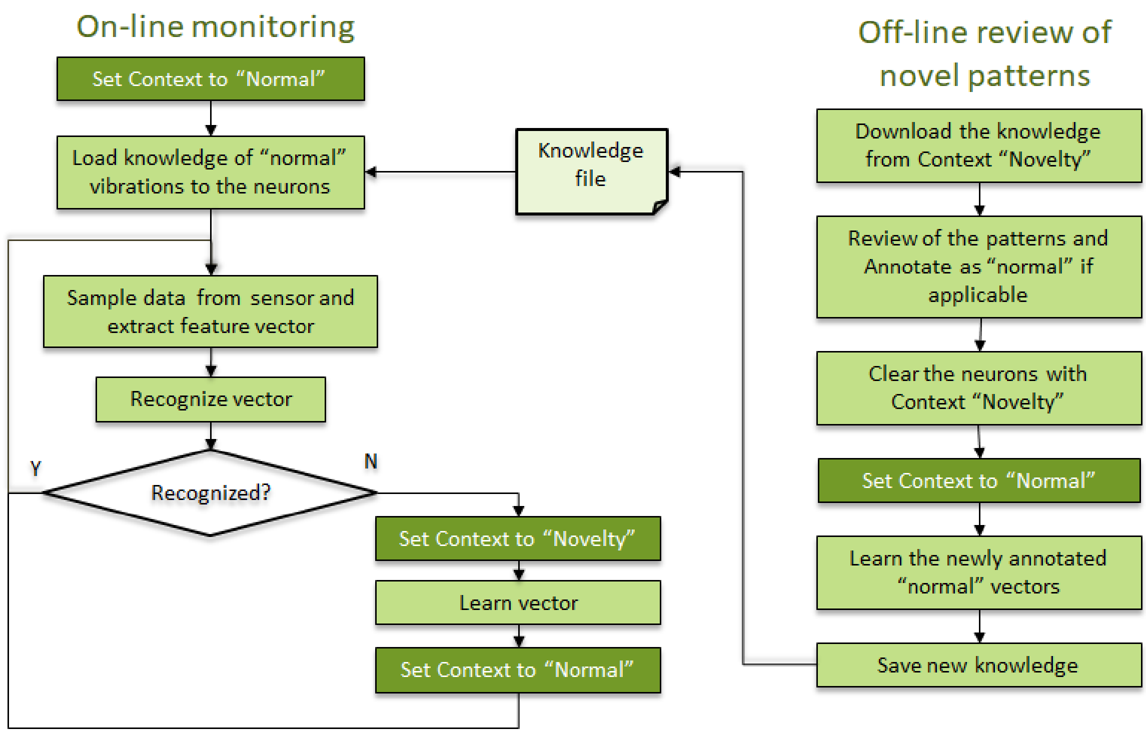
Learning can be performed using tools supplied by General Vision such as its NeuroMem Knowledge Builder and Software Development Kits for MATLAB and more.

The output of this learning phase is nothing more than the content of the neurons which have been assigned to a “Normal” context. This is what be call the “Normal” knowledge.

EXECUTION ENGINE

This is where the chipset NeuroMem+(FPGA or MCU) comes to action.

The state machine is basically continuously acquiring signal, extracting a type of signature vector defined ahead of time, broadcasting this vector to the neurons for recognition under a context “Normal” and simply monitoring the recognition status accessible through 2 output lines of the chip, ID and UNC, or by reading the NSR register. This readout takes 1 clock cycle. When the status is Unknown, the state machine set the context to “Novelty” and sends a Learn command to the neurons (i.e. Write category). It then immediately sets the context to “Normal” again and loop.



The uniqueness of NeuroMem to record anomalies resides in 5 facts:

- Recognition status is known 1 clock cycle after the broadcast of the vector (28 nsec)
- The learning of the novel pattern does not require to re-broadcast it
- The learning is executed in less than 22 clock cycles, regardless of the number of "novelty" neurons already committed (0.5 µsec @36 Mhz)
- The learning is guaranteed of no duplication
- The data base of detected novelties resides in the neurons themselves (belonging to the context "Novelty", so the chipset does not require any extra memory
- During the off-line review phase, it is possible to decide that a novel pattern be taught as something else than "Normal", but rather a new category such as "Normal state 2", or "Acceptable Drift" or else. It all depends on the application, but the neurons can be very instrumental at identifying new categories.

CONCLUSION

NeuroMem has unique features for anomaly and novelty detection which makes it the only commercial neuromorphic chip suitable for real-time condition monitoring, predictive maintenance, and failure analysis. Its small footprint and low power consumption make it ideal to reside next to the sensors and be integrated into battery powered wearables and appliances.