Anomaly Detection in Sensors Data

CUSUM Algorithm

Algorithm:

```
Cusum-Anomaly-Detection(T, threshold, drift)

    S₀ = 0, g₀⁺ = 0, g₀⁻ = 0

    for t in range 1 to number of measurements do:

        Sₜ = Tₜ - Tₜ₋₁

        gₜ⁺ = max(gₜ₋₁⁺ + Sₜ - drift, 0)

        gₜ⁻ = max(gₜ₋₁⁻ - Sₜ - drift, 0)

        if gₜ⁺ > threshold or gₜ⁻ > threshold then:

            talarm.append(t), gₜ⁺ = 0 gₜ⁻ = 0

    return talarm
```
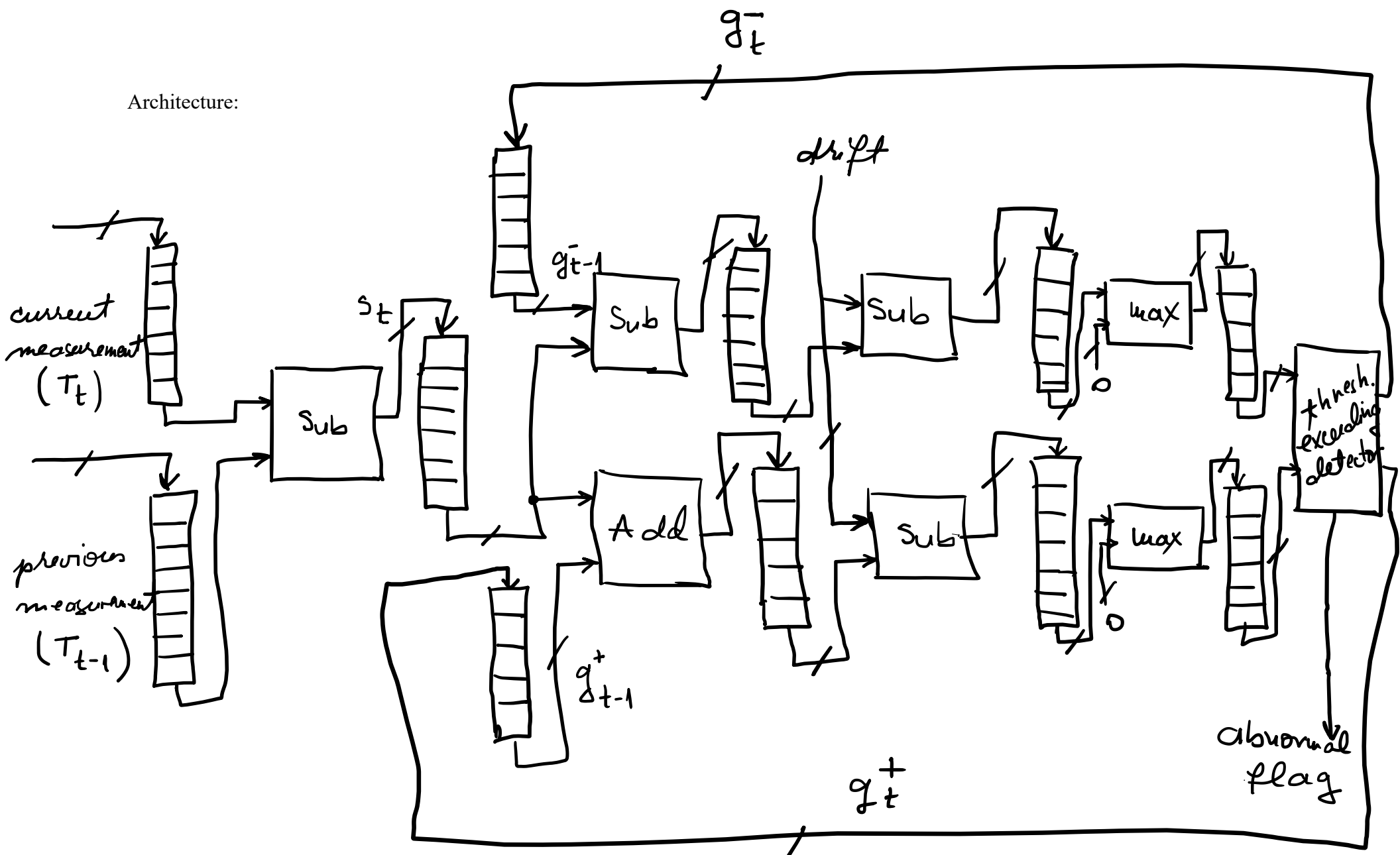
- `T` – the dataset
- `threshold` – maximum normal variation between two consecutive measurements
- `drift` – parameter used to reduce the number of FP (false positive observations)

Hardware Architecture designed based on this algorithm follows a streaming approach and uses FIFO buffers between the processing units which perform computations.

Components:

- `Add/Sub` – adder or subtractor
- `Max` – unit which outputs the maximum value of inputs
- `Threshold exceeding detector` – unit which checks if any of g_t^+ or g_t^- exceeds the threshold given as input and

Architecture:

current measurement (T_t)

previous measurement (T_{t-1})

Sub

s_t

g^-_t

g^-_{t-1}

Sub

drift

Sub

max

0

thresh. exceeding detector

Add

g^+_{t-1}

Sub

max

0

g^+_t

abnormal flag

Implementation details:

1. Implementation for floating point data type

Sources:

- `fp_max` – unit to get the maximum value of inputs
- `threshold_exceeding_detector` – unit which checks if computed values for g_t^+ and g_t^- exceed the threshold
- `cumulative_sums_detector` – top module

2. Integer Implementation for integer data type

Sources:

- `int_adder_subtractor` – adder/subtractor with AXI-Stream I/O interfaces for adding or subtracting two integers
- `int_max` – unit to get the maximum value of inputs (integer)
- `int_threshold_exceeding_detector` – unit which checks if computed values for g_t^+ and g_t^- exceed the threshold

Additional sources used for programming the basys3 device are: `mpg`, `fp_rom256x32`, `diplay_7seg`, `rom256x32` and `counter32`.

Testbench files' names begin with "`tb_`".