temporal.

A Summary

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Temporal Computing Ltd is a startup which specialises in an unconventional approach to computation using time as the main representation of data. The temporal domain (essentially the forward passage of time) can be thought of as a free resource, it costs very little to mark intervals in time and is remarkably efficient at quite sophisticated arithmetic operations (such as dot products). This original theoretical work was carried out with the support of York University's Non-standard Computation Group and widely published in the field of unconventional computation between 2014 and 2016.

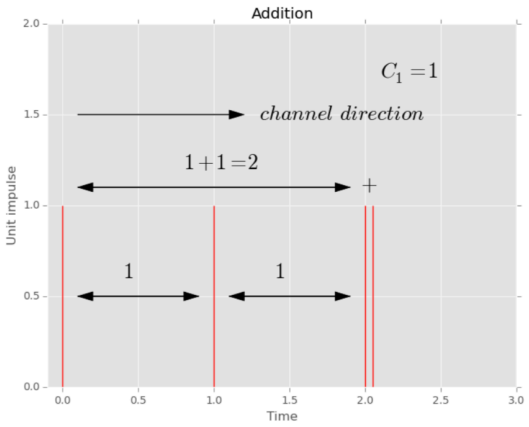
We are at the very early stage of assessing the practical impact of our ideas, but there is a real need for decreased power usage and increasing speed given the applicability of deep learning models, which we hope our technology can provide.

Motivation

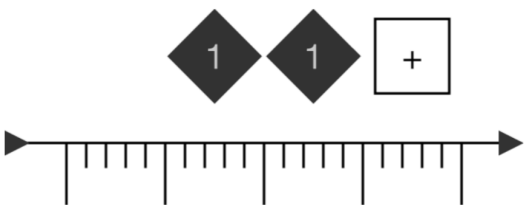
Current Central Processor Unit (CPU) design is fixated on binary digital data storage. We take a step back from this approach, exploring an alternative method of performing computation without the storage and manipulation of binary data.

Time Coding: The Central Idea

Values are represented by the interval or delay between impulses on a channel. Computation is performed by manipulating the impulses and delays. We can represent the operation 1 + 1 like this:



First is the pattern indicating the operation (addition), then the impulses delimiting the arguments to the operation. We can also use the following cleaner graphical notation for the above:



We have extended this idea to incorporate multiplication, multiplexing and a collection of neurally useful (eg. dot products, quadratics and maxima) operations.

Potential Advantages

1. **Time is free** and the encoding has a different energy pro- file to binary. Typically a binary pulse is up to nine times more valuable information wise than a binary bit.[1]
2. Computation in the temporal domain has some significant and surprisingly valuable advantages over and above addition, there appears to be **less symbol manipulation** required for key functionality, which at a fundamental level improves processing efficiency.
3. Because of this simplification, it is envisaged that **simple parallel processing elements** with memory and computation close and systolic can be implemented.
4. The implementation medium is so general that it **may live outside of the silicon medium**, in fact mediums with implicit oscillation (clock timing) may exploit the encoding more readily.
5. **Time is an invariant** so physical medium boundary cross- ing like ADC and DAC aren't necessary.
6. **Data is often temporal** (for instance LIDAR) - so we can process it in its natural form without TDC (time to digital conversion).

Challenges

1. Getting the correct medium - we are currently investigating traditional digital/silicon approaches but this might not be the best.
2. Synchronisation - if small parallelised units are to be explored we need to talk asynchronously.
3. Interfacing with traditional methods - we can't ignore digital.
4. Binary has a 70 year head start! We are starting from scratch.

[1] Page 135 - Donald M. MacKay · Warren S. McCulloch, The limiting information capacity of a neuronal link Article in Bulletin of Mathematical Biology14(2):127-135 January 1952