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A Fast General-Purpose Clustering Algorithm Based on FPGAs for High-Throughput Data Processing

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We present a fast general-purpose algorithm for high-throughput clustering of data "with a two dimensional organization". The
algorithm is designed to be implemented with FPGAs or custom electronics. The key feature is a processing time that scales
linearly with the amount of data to be processed. This means that clustering can be performed in pipeline with the readout, without
suffering from combinatorial delays due to looping multiple times through all the data. This feature makes this algorithm especially
well suited for problems where the data has high density, e.g. in the case of tracking devices working under high-luminosity
condition such as those of LHC or Super-LHC.
The algorithm is organized in two steps: the first step (core) clusters the data; the second step analyzes each cluster of data to
extract the desired information. The current algorithm is developed as a clustering device for modern high-energy physics pixel
detectors. However, the algorithm has much broader field of applications. In fact, its core does not specifically rely on the kind of
data or detector it is working for, while the second step can and should be tailored for a given application. For example, in case of
spatial measurement with silicon pixel detectors, the second step performs center of charge calculation. Applications can thus be
foreseen to other detectors and other scientific fields ranging from HEP calorimeters to medical imaging.
An additional advantage of this two steps approach is that the typical clustering related calculations (second step) are separated
from the combinatorial complications of clustering. This separation simplifies the design of the second step and it enables it to
perform sophisticated calculations achieving offline-quality in online applications. The algorithm is general purpose in the sense
that only minimal assumptions on the kind of clustering to be performed are made.

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