Application of Fully Parallel Associative Memory in Two-Stage Pattern Matching

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Introduction

Motivation

To find the nearest match for an input-data of W-bit length among R reference data words with a fully parallel processing.

Euclidean distance measure is advantageous in terms of giving an actual distance between two points in the real space.

Two-stage winner search system significantly improves the reliability of pattern matching or vector quantization recognition.

Application Examples

(a) Vector-quantization recognition

(b) Code-book-based image compression

Features

The realization of k-nearest-matches search capability in fully-parallel mixed digital-analog associative memories by a sequential autonomous search mode is reported.

The proposed concept and circuit implementation can be applied with all types of distance measures such as Hamming, Manhattan or Euclidean distance search.

The value of k is arbitrarily selectable during operation.

Two-Stage Pattern Matching System

Main Search Data (SD)

First Associative Memory (AM1) Containing Main Reference Data

Priority Encoder

Column Decoder

Address

Write

Search

Additional Feature Data may contain the features like:

1. Total mass
   (no. of black pixels)
2. Centroid
   (average of horizontal and vertical projections)
3. Eccentricity
   (ratio of major to minor axis)
4. Orientation
   (angle of major axis)
5. Skewness

The two-stage pattern matching system consists of two associative memory blocks, one for the main reference data and another for additional feature reference data.

Hybrid distance measures like Hamming/Manhattan distance in the first associative memory and Euclidean distance in the second can be possible.

After searching the first k nearest-matched reference patterns within the first associative memory and finding the nearest-match addresses, the corresponding lines in the additional feature memory will be activated for the final winner search. The second-stage winner search in the additional feature memory will be done among the k nearest-matched rows searched by the first associative memory.

Architecture Circuit of the K-nearest-matches Search

- k-bit digital subtractor and absolute value calculator and analog squarer are used to realize Euclidean distance search.
- All unit comparators and all word comparators calculate the distance between search word and stored word in parallel.

Search Data (K x W)

Winner Line-up Amplifier (WLA)

Winner Take-all Circuit (WTA)

Winner

Input

Feedback Element

Output
The k-nearest-matches search system designed in 0.35 µm, two-poly, three-metal CMOS technology consumes only 5.12 mm² area and contains 64 reference patterns with 16 binaries each 5-bit long.

The k-nearest-matches search unit consumes only 0.64 mm² which is 12.5% of the total design area.

From the simulation result we can see that the first winner is searched in first clock cycle when the enable signal is high, after that the first winner becomes a loser during the entire simulation time. Similarly, in the next clock cycles the 2nd, 3rd, 4th winners up to a selectable k can be searched.

The proposed system has been tested and results are compared with the system which uses single stage recognition.

The proposed system reduced the misclassification rate of the handwritten character recognition system from 13% (with single stage) to 5.3%.

A mixed digital-analog cascaded associative memory based system with two-stage winner search is proposed.

Two-stage pattern matching system significantly improves the reliability of object recognition system.

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Since both the associative memories in the two-stage pattern matching system can be used for different distance measures, it is possible to implement a hybrid distance measure.