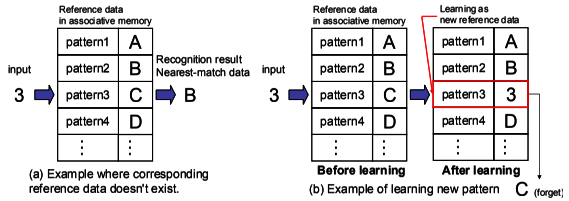
Associative-Memory Function

- High Speed Nearest-Match Reference Pattern Search
  (Hamming or Manhattan Distance)



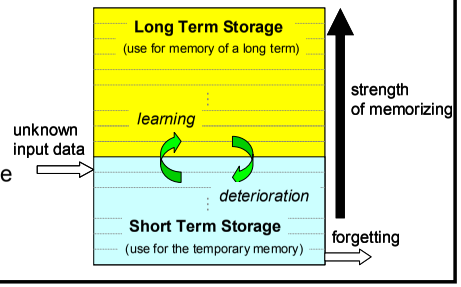
Application for pattern recognition and learning system

Short/Long Term Storage Concept

Imitate the short-term and the long-term memory of the human brain (Cognitive Science).

Short-Term Memory
New information is temporarily memorized.

Long-Term-Memory
Reference pattern can be memorized for a longer time without receiving the influence of the constantly changing input patterns.



Comparison with Existing Method

Processor Based

- The comparison of the distances of input-data and all reference-data requires a long processing-time due to serial processing.
- The processing-time problem becomes very serious when pattern length and number of reference patterns increase.

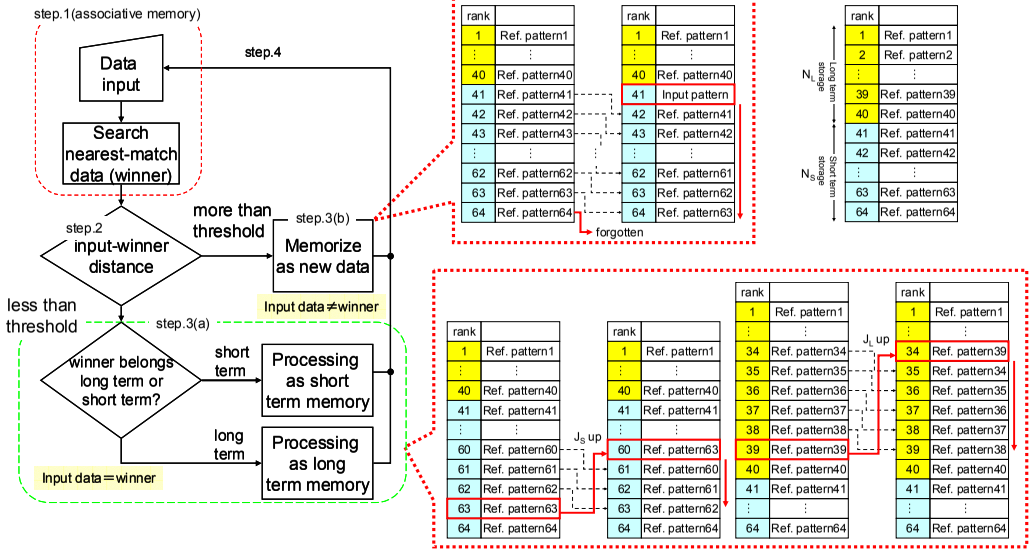
Neural Network Based

- Complicated training is necessary at the beginning to enable the recognition of new data.
- Building into LSI is difficult. → Large Scale, Power Dissipation, Many Interconnects

→ Associative-Memory Based

- Comparison between the input-pattern and each reference-pattern is executed at high speed by mixed analog-digital fully-parallel processing.
- Learning of new patterns by simply storing them in memory.
- Easy integration with present CMOS technology.

Automatic Learning Algorithm



Step1. The associative memory searches for the pattern, which is the nearest-match (winner) to the input pattern among the reference patterns.

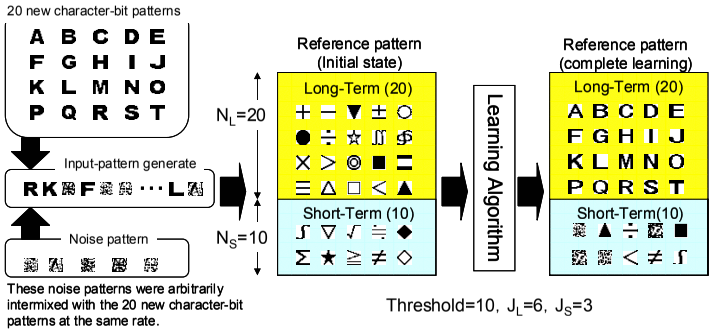
Step2. The distance "D" between input pattern and winner-pattern is calculated.

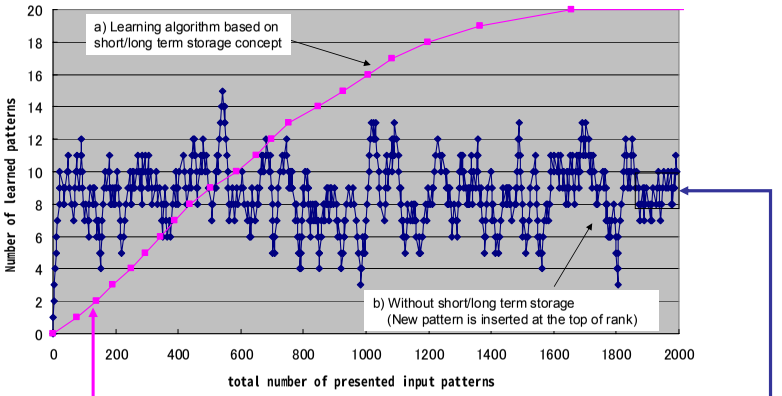
Step3(a). "D<threshold" → Input pattern and winner-pattern are considered to be the same. The rank of the reference pattern that became the winner is raised.

Step3(b). "D≧threshold" → The system considers these two patterns to be different. Inserts the winner pattern at the top rank of the short-term memory to learn new data. The reference pattern with the lowest rank in short-term memory is erased and forgotten.

Step4. Whenever input data is given to the system, processing from steps 1 to step 3 are repeated.

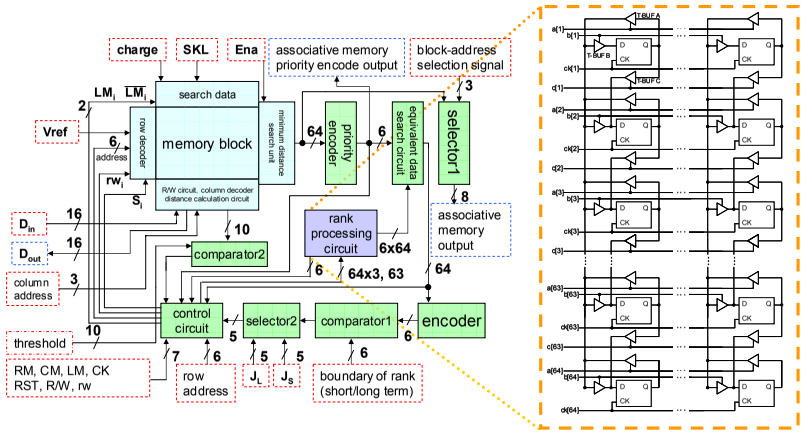
Simulation and Test-Chip Design

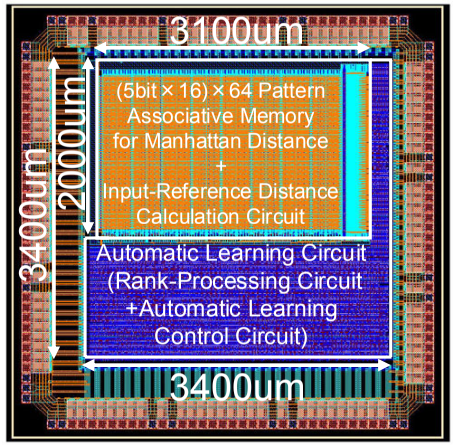


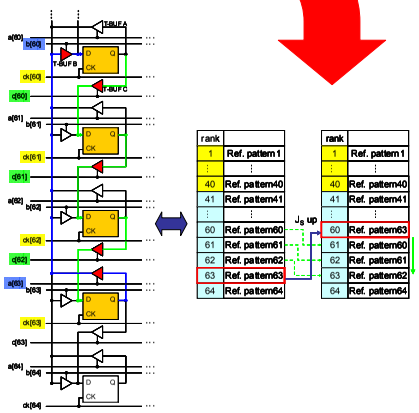


The short/long-term memory concept and the transition mechanism from short-term to long-term memory have the effect that noise patterns are unable to advance from the short-term to the long-term memory.

Due to the intermixed noise patterns, the new character-bit patterns cannot be learned efficiently. The number of learned patterns oscillates around 10 due to the noise intermixture rate of 50%.







Distance Measure	Manhattan Distance (5bit × 16)
Reference Patterns	64
Short Term Storage	24 (Default, Variable)
Long Term Storage	40 (Default, Variable)
Nearest-Match Range	0～496
Technology	0.35um, 2-poly 3-metal, CMOS
Supply Voltage	3.3 V
Number of Transistor	402,768
Design Area	11.04mm^2
Associative Memory	6.20mm^2
Automatic Learning Circuit	4.84mm^2
Automatic Learning Algorithm Processing Time	< 290nsec (Search time 250nsec)
Automatic Learning Circuit Max Operation Frequency	166MHz (gate-level simulation)