CNN Technology in Action

Demo Session

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ABSTRACT: *Two CNN-UM prototypes are demonstrated in action. The first one is the latest 4096 cell-processor, analog I/O, analogic CNN Visual Microprocessor, on which on-line video image processing will be performed. The second one, the 20x22 binary input-binary output CNN-UM chip is introduced as an ultra high-speed focal plane array processor. In the live demonstration it captures and classifies 10,000 frames in a second.*

1. Introduction

In the last few years the analog VLSI CNN chips [1,2,3,4] and their embedding software-hardware environment [5] reached a high sophistication level, which makes the CNN technology ready to be applied in industry or in commercial products. This session is devoted to demonstrate the advanced features of the new CNN chip based systems.

The demonstrated analogic CNN visual microprocessors were designed in the *Institute of Microelectronics of Seville of the Spanish National Microelectronics Center.* Using the CNN-UM chips, the first prototypes of a visual computer (called Aladdin) was designed and built in the *Analogical and Neural Computation Laboratory of the Computer and Automation Research Institute of the Hungarian Academy of Science.*

The first demonstration (Section 2) introduces the 64x64 CNN-UM chip [3] as an on-line video flow processor, while the second one (Section 3) applies the 20x22 chip [4] as an ultra high-speed focal plane array.

2. On-line video flow processing

Motivations: In the last few years particle detection and classification in fluid-flows have received considerable interest among the applications requiring image processing at ultra high frame rates. For instance, a sensory module capable of identifying the density of debris particles in the oil-flow of various engines would enable a cost-effective on-line monitoring of these systems (e.g. condition based monitoring of jet engines).

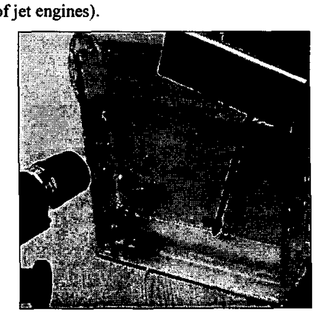

Figure 1. The experimental setup of the marble-bubble detection system.

Cellular neural/nonlinear network (CNN) technology offers a parallel and analogic (combined analog and logic) approach to these problems. The CNN chip can be used either as a focal-plane array processor or a ***video-flow processing visual microprocessor.*** In the latter case recent feasibility studies

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and experiments indicate that in a demo prototyping system detection and classification of the particles can be performed on-line on a 64x64 CNN chip [3].

Task specification and the demo system: Figure 1 shows the experimental setup of the on-line video-flow demonstration. In a water tank containing bubbles and marbles, a fast turbulent flow is generated. The task is to detect and separate the marbles from air-bubbles in each acquired image. The demonstration aims to prove that a morphology based complex algorithm can be executed during an *on-line vide-flow processing in a CNN system.*

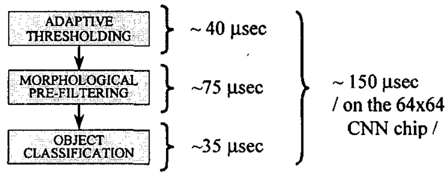

Figure 2. The flow-chart of the marble-bubble detection algorithm. The time requirement of each steps is also indicated.

General idea of the solution: (i) *adaptive thresholding*: all objects are detected in the image field through a spatially adaptive thresholding, (ii) *morphological pre-filtering*: objects are compared to prototype objects to filter out single bubbles and bubble-groups, furthermore to classify the remaining objects into different particle groups, (iii) *object classification*: in the last stage objects are classified based on their size and morphology (and a simple statistics is calculated for different object groups). The on-chip time performance of major subroutines of the algorithm is summarized in Figure 2 (no transfer and display time included):

3. Ultra high frame-rate image capturing and processing

Motivations: Ultra high frame-rate (exceeding 10 000 frame/sec) image processing is an unsolved problem with current digital systems of affordable price and size. Both the limited computational power and the I/O bottleneck (when the image is transferred from the sensor to the processor) represent major obstacles in digital systems.

Cellular neural/nonlinear network (CNN) technology offers a parallel and analogic (combined analog and logic) approach to these problems. If a CNN chip is used as a focal-plane array, the zero computational load requirement is satisfied immediately. This chip [4] acts as ***a focal-plane visual microprocessor***: acquires image frames parallel through the optical input, transfers them to the processor elements and performs the analysis also in parallel. In **20 µsec**, approximately 5 analog operations (CNN templates) and 10 local logic operations can be completed. This makes it possible that even a complex morphological decision can be performed within two subsequent frames at a **50 000 frames/sec** operational speed.

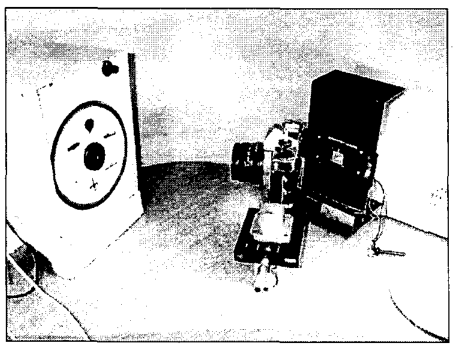

Figure 3. The experimental setup of the ultra high speed, focal plane array processor system.

Task specification and the demo system: The experimental setup is shown in Figure 3. The CNN platform which carries the chip is mounted on the back panel of a camera (only the optics is used, no shutter is required). On a rotating disk different images are posted and during the experiment these images are projected to the chip through the lens system of the camera. The demonstration proves that the system is able to classify six different flying objects (hot-air balloons and airplanes) based on their silhouettes' low resolution projections on the chip's optical sensors at a speed of approximately 10 000 frames/sec. In Figure 4 the major subroutines of the algorithm are shown along with their measured on-chip time performance (no transfer and display time included). Detailed description of this experiment can be found in [6].

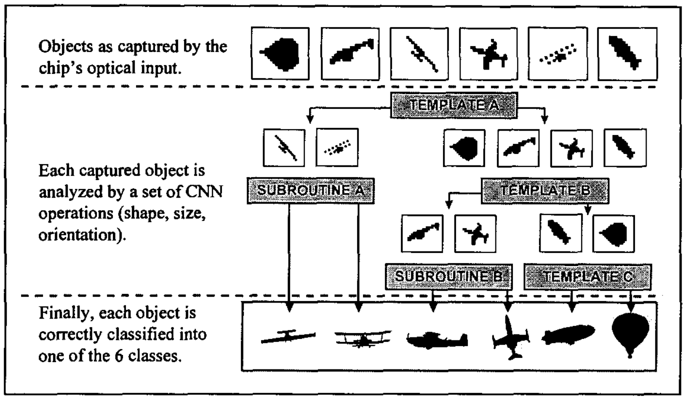

Figure 4. The flow-chart of the image classification algorithm.

4. Conclusion

Analogic visual computers, based on CNN technology are demonstrated in action. It is proved that the CNN technology is ready to be applied in industrial vision application or in commercial products.

References

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