Ultra Fast Object Counting Based-on Cellular Neural Network

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***Abstract*— Vision based counter systems are very important tools in industries. Movement of objects on conveyer systems at a high speed requires an accordingly very fast processing. Therefore, traditional methods for object counting are not efficient due to the fact that they are generally slow. In this paper a CNN based method for counting objects. Simulation results for this method shows that this system is very applicable for object counting at very high speed conveyers. By just a few reconfigurations in CNN templates coefficients, we are able to modify this system for other similar applications.**

Keywords— Cellular Neural Network; Image Processing; Object counting; Simulation.

I. Introduction

Some of the main applications of object counting in industrial systems are packaging, quality control, and so on. Object counting in conveyor in traditional method is based on a simple digital camera and a central processing unit. In the first step, by an external trigger mechanism, camera starts to grab a picture immediately. By some new CMOS cameras we are able to grab pictures very fast and accurate. The main topic and bottleneck is processing time. A blob finding algorithm for labeling and indexing objects is very time consuming. After applying preprocessing algorithm on image for increasing the quality we need to segment the important parts of the picture. For this we use a threshold or dynamic threshold method. This part is our Region of Interest (ROI) for next step. By a connection method that is very time consumer we can index and label or parts and objects. In our approach that we will introduce in this paper, we will shows a CNN based method for counting object without passing this time consuming steps. Cellular Neural Networks (CNN), proposed by Leon Chua in 1988. The main aim of CNN technology is designing of an ultra fast Universal Machine for signal processing purposes.

II. Cellular Neural Networks (CNN)

Cellular Neural Network were introduced by Leon O. Chua and Yang from university of California at Berkeley in 1988. This type of neural networks is a somehow reduced version of Hopfield Neural Network. One of the must important features of CNN is locally connectivity, in this technology each cells is connect only to neighbor cells. Due to locally connection between a cell and the neighbors, implementation of this type of neural network on chip is easily feasible. The mathematical model of a CNN cell is a first-order equation like the following state equation:

$$\textit{State Equation}$$

$$C\frac{dv_{xij}(t)}{dt} = -\frac{1}{R_x}v_{xij}(t) + \sum_{C(k,l)\in N_r(i,j)} A(i,j;k,l)v_{ykl}(t) + \sum_{C(k,l)\in N_r(i,j)} B(i,j;k,l)v_{ukl} + I$$

$$1 \le i \le M; 1 \le j \le N$$

In this equation 'A' is a template for feedback operator and 'B' is a template for control. Output Equation is a linear sigmoid function for limiting output state value. In some note sigmoid function enumerate by f (.).

$$\textit{Output Equation}:$$

$$v_{yij}(t) = \frac{1}{2}\left(\left|v_{xij}(t)+1\right| - \left|v_{xij}(t)-1\right|\right)$$

$$1 \le i \le M \; ; 1 \le j \le N$$

III. Object Counting Based on CNN

In this section we will describe algorithm for object counting based on CNN. A block diagram that shows the system algorithm is showed in figure 1. After picture grabbing, and picture enhancement unit, this algorithm begins. A selected image for simulate and testing of algorithm is a 64×64 pixel image with 256 level gray level depths that is shown in figure 2. Subsequently, by applying first step of algorithm, image converts to a binary image black and white.

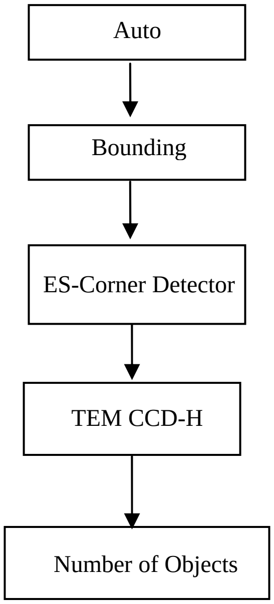


Figure-1, Diagram of object counting algorithm based on CNN technology

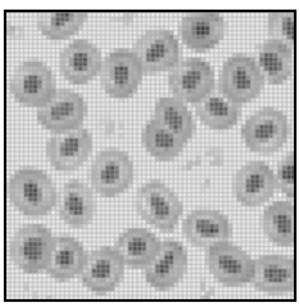


Figure-2, Original Image, 64×64 pixel and 256 gray level bitmap.

The first step of this algorithm shows the auto threshold unit. This unit is a unique and valuable operation that can select opaque region and remove noise on around of image. Traditionally, for designing this operator, designer had to combine many low level operators, like threshold, median filter and noise remover. Auto threshold consists of below templates:

$$A=\begin{bmatrix}0&1&0\\1&4&1\\0&1&0\end{bmatrix}, B=\begin{bmatrix}0&0&0\\0&-1&0\\0&0&0\end{bmatrix}, I=1$$

Effect of feedback template (A) is very important. Another alternative for this template for having a smoothed result is an 8 value in center and 1 value in around.

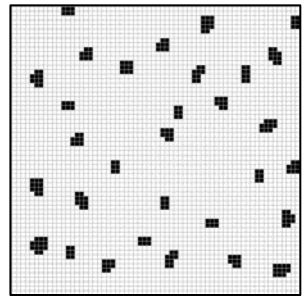


Figure 3, Auto Threshold Template Result.

After this step, system runs the Bounding Box Template.

$$A=\begin{bmatrix}0&1&0\\1&2&1\\0&1&0\end{bmatrix}, B=\begin{bmatrix}0&0&0\\0&0&0\\0&0&0\end{bmatrix}, I=-2$$

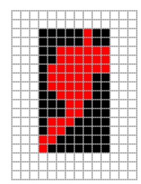
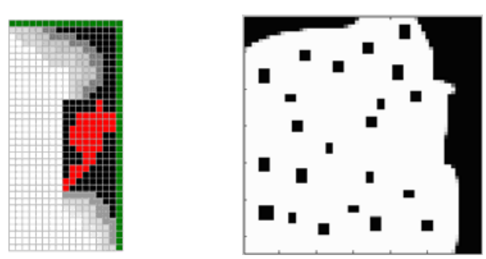


Figure-4, Bounding Box Template Result after converge time, Red region is the initial state.

This operator is very sensitive, and we must consider to something. Applying Bounding Box template on below red region shows that, system converges to a rectangular shape. But it cause to problem when a region is connect to a boundary margin in CNN chip. This problem cause to grow-up of bounding box in an unenviable manner. This problem shows in figure 5.



(a) (b)

Figure 5, (a) Bounding Box Template fails when a region is connected to margin. (b) Step=10, simulation result

To solve this problem, we must remove margin by an AND template. Figure 6, shows the result of bounding box template after removing margin boundary.

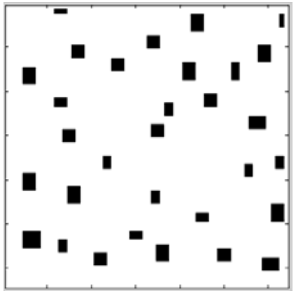


Figure 6, Bounding Box Result

There is an effective South-East Corner finder template that can select the S-E Corner of each rectangle.

$$A=\begin{bmatrix}0&0&0\\0&0&0\\0&0&0\end{bmatrix}, B=\begin{bmatrix}0&0&0\\0&-1&-1\\0&-1&3\end{bmatrix}, I=5$$

By this method, we are able to convert each rectangle to a pixel. Notice that some pixels are located on the right margin of frame. Therefore for the next step, we must apply left to right (Connected Component Detector) CCD template. Otherwise it will draw a shadow, and cause to fail.

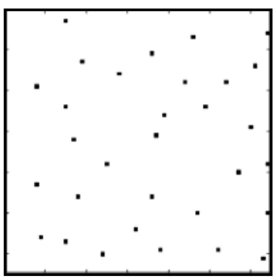


Figure 7, SE Corner Detector Result

Figure 8, shows the connected component detector template result. Now by counting of pixels, the number of objects will obtains. It should be mentioned that this algorithm couldn't distinguished two objects that have an overlap. For distinguishing overlap object we need to use shape based matching algorithms.

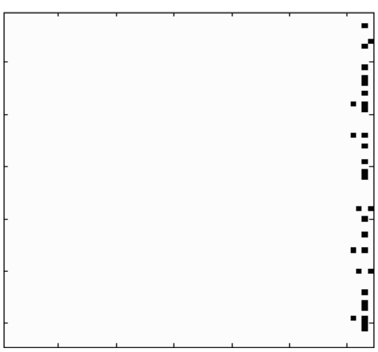


Figure 8, Connected Component Detector (CCD) Result

IV. Conclusion

The simulation results for this method show that this algorithm with reduced operators based on CNN technology is very effective and reliable for ultra fast object counting. Extensions of this system are very simple and all template values that used in this simulation are in regular range of VLSI technology CNN chips [-5 ~ +5]. For the future work, we are going to improve this system for detecting and distinguishing of overlapped objects.

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