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PERMANENCE MEMORY: A SYSTEM FOR REAL TIME MOTION ANALYSIS IN IMAGE SEQUENCES

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Abstract.

This paper sets forth a system for motion analysis in image sequences.

We start out from sequences of binary images, segmented by thresholding methods of gray levels, or with other type of parameters; nevertheless, the objetive of our work does not lie in this phase of segmentation. Our work is focused on the analysis of parameters of motion with this type of binarized sequences. Our proposal as a resolution method is the use of an intermediate memory, which stores information about the background of each pixel in the sensor. By analyzing this memory, called permanence memory, we will be able to obtain interesting motion parameters and features. The system offers the possibility to be implemented in hardware to work in real time with image sequences. The aim of this paper is just to expose the concept of permanence memory and to propose its use for motion analysis in image sequences. This is the reason why we just put forward basic examples so as to clarify the concept without getting entangled with the problems characteristic of implementation, which will be clarified in further more specific works about particular applications.

Problems of motion analysis of image sequences in real time

Motion analysis in image sequences has classically been studied with optical flow-based systems [1] and [2], or with those based on accumulative differences [3], or on some other correlation-based processes. The main problems which arise from motion analysis with system based on the calculation of optical flow resides in the complexity of the calculations required which do not allow to work in real time. Those systems based on accumulative differences can not be applied for image sequences from moving sensors, due to the fact that it is not possible to determine a reference image. Some other systems based on correlation allow the location of known elements but do not allow speed analysis globally for any element in the image. Our proposal provides a solution for such problem, allowing the realization of systems which analize, in real time, the motion of different image elements, even in the case of sequences of moving sensors. Logically, our proposal also presents some drawbacks. Although the binarization stage could be thought to cause additional problems, that is not true, since the rest of the procedures based on the use of the image with all its range of grays, share the limitations involved in this type of image sequences with variations of gray levels which are not due to image elements motion but to variations in the lighting, image noise, and other causes. Problems of this kind are not additional but transferred to other stages in the process.

Resolution proposal by means of permanence memories.

We propose a solution for this kind of problems, which can be applied in a wide variety of real events, and also offering the possibility of hardware implementation to work in real time: systems based on permanence memories.Let us explain the concept, operation and limitations.

Concept of Permanence Memory:A permanence memory consists of a system made up of a mamory and a logic with the following features:

The memory must have a storing capacity so that it can store as many data as image pixels the sensor can detect in one image frame, or at least, as many

as the image area we wish to process.
The logic actualizes the data in the permanence memory with the following algorithm.

IF f(X,Y) = 1 THEM
D(X,Y) = D(X,Y) + S
(maximun MAX)
IF f(X,Y) = 0 THEM
D(X,Y) = D(X,Y) - S
(minimum MIN)

Where :
- f(X,Y), is the image binarized pixel value.
- D(X,Y), is the value in (X,Y) position in permanence memory.

Hence, we see that the value of each datum in this permanence memory will depend on the time interval transcurred from the moment the binarized image took value one in that same pixel. As a result of this, a pixel of coordinates (X,Y) would be "suddenly activated" when the image had value one in that pixel. And it would be "slowly desdactivated" as long as the image does not take value one again for that pixel.
By choosing conveniently the values for S,R, MAX, and MIN we will obtain further information about the most immediate background of each pixel in the sensor.
Figure 1 shows the graphic of a sequence, the value of each datum being represented with bars in an area of the permanence memory.

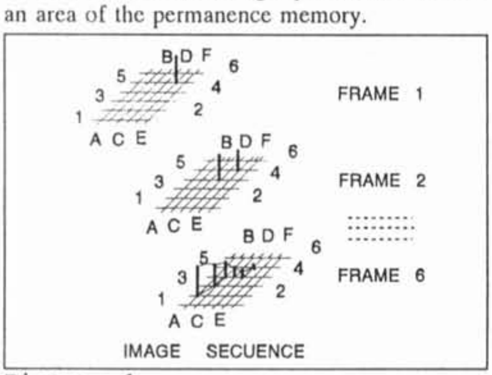

Figure. 1

Frame 1 of the already binarized image sequence shows pixel E5 as 1 (activated).In the permanence memory,the datum whose direction coincide with the activated position will add S to its value. This is indicated by elevating the heighth of the corresponding column a determinated quantity S. In the second frame of the sequence, the pixel which appears as activated is pixel D4, due to the motion of the image element. Its corresponding position in the permanence memory will add S. And the position of pixel E5 will subtract R. With the flow of new images of the sequence, the moving pixel will gradually create a "trail" in the permanence memory. The analysis of this trail will provide information about the pixel motion.

Outline of a system based on permanence memories: Let us assume that when we refer to

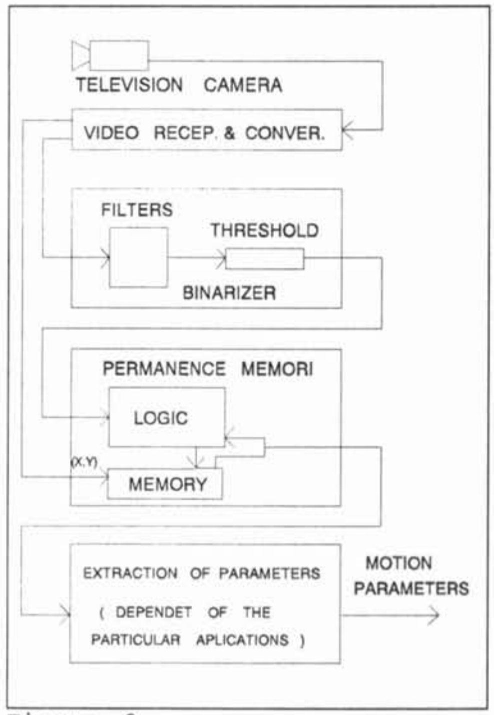

Figure. 2

real time, we mean a vision system based on the CCIR standard norm and with a 10 Mhz digitalization.But it is also worth noting that those systems based on permanence memories can be applied to different working environments in conditions which may differ from ours. Figure 2 shows the graphic of the system structure.The video reception block carries out tasks of sincronisms extraction, digitalization, coordinates count,etc., and can be designed through circuitry which is classically used for this type of system, reason for which we do not give further information.
The binarization submodulus converts each pixel into a binary value. This conversion will depend upon each particular application, and could be based on a simple thresholding of gray levels or on the analysis of other type of parameters, such as the result of two-dimensional filters in the neighboring of the pixel to be binarized. In any of the former cases, these operations can be accomplished with commercial hardware in real time.
As it has already been explained, the permanence memory consists of a high speed static RAM and an addition logic conditioned to the value of binarization of the pixel to be actualized. This task can also be accomplished in real time. Actualization of the permanence memory can be adequated through constants S and R in order to

obtain the most convenient information for each particular case.

Finally, the nature of the submodulus devoted to establish the value of the parameters trough the analysys of the permanence memory has a strong dependence upon the information we wish to obtain. The following section will discuss this item.

Permanence memory analysis for the obtention of motion parameters: Permanence memories can be applied to different kinds of image sequences analysis. Some of these cases are presented in the section dedicated to other applications. Let us now try to classify the different types of analysis which can be accomplished with this sytem.

Let us differentiate two types of processes: local and global processes.

A local process does not process all the pixels in the permanence memory;only a subgroup of them. An example of this is the random access of a processor to the permanence memory. By analyzing particular trails the processor can accomplish the calculation of the speed modulus and the trajectory of the element in its most immediate background.

Another wide range of possibilities is offered by global processes. By using specific hardware the permanence memory can be processed trough gradient methods in order to get information about which elements are associated to specific speeds, which elements differ in trejectory with respect to the rest of them and which is the quantity of motion in the scene.

It is worth while remarking that we face the possibility to create systems which can accomplish, with the same permanence memory, both global and local analysis simultaneously.

Simulation

The systems described above have been tested and this type of analysis has been simulated off-line with synthetic image sequences.

Several sequences of synthetic binary images have been processed in order to actualize an area of the memory which simulates the permanence memory. The analysis, by means of software in language C, of this simulated permanence memory allows us to draw conclusions about the motion of the image elements, which correspond with the motions synthetically generated in the sequences.

Figures 3,5 and 7 show, in some intentionally simple examples, how some permanence memories look like after transformation of their values in gray levels,and in the corresponding graphics 4,6 and 8 we can see the results of the analysis carried out with the permanence memory.

- Figure 3. Actualized permanence memory through a sequence in which a square is moving with a uniform straight motion.

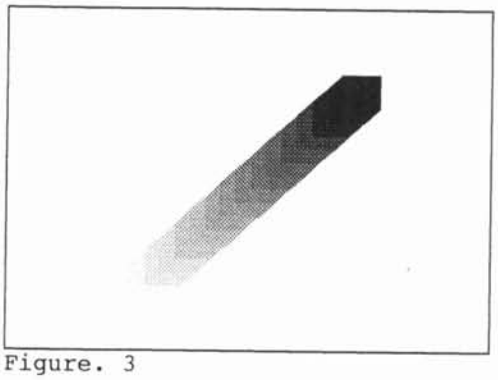

Figure. 3

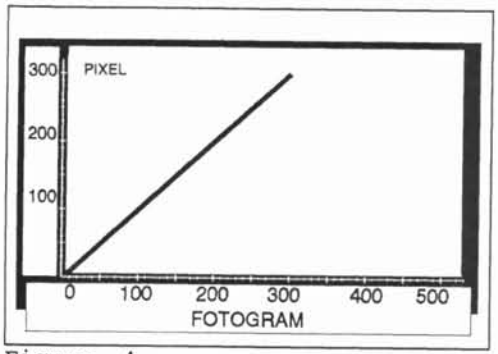

Figure. 4

- Figure 4.Space-Time graphic (pixel-frame) resulted from the analysis of the permanence memory in fig.3.

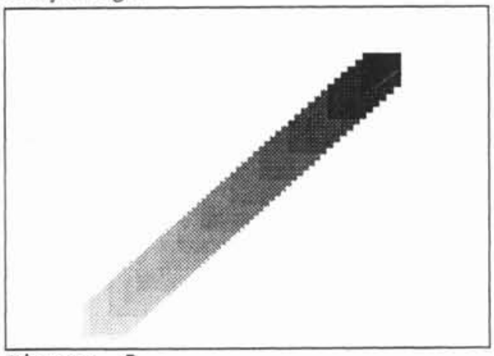

Figure. 5

- Figure 5. Actualized permanence memory by means of a sequence in which a square is moving with a straight constannt acceleration motion.
- Figure 6. Space-Time graphic (pixel-frame) resulted from the analysis of the permanence memory in fig.5.

- Figure 7. Actualized permanence memory through a sequence in which a circle is moving with a uniform spiral motion.

- Fig. 8 . Graphic of the trajectory resulted from the analysis of the permanence memory in fig.7.

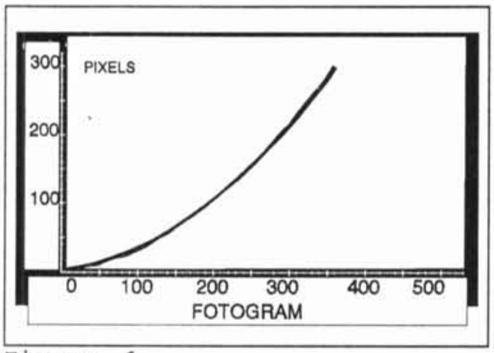

Figure. 6

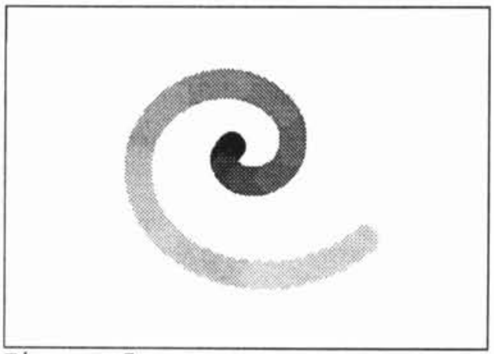
Figure. 7

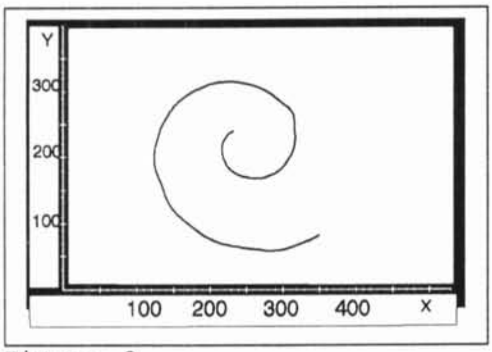

Figure. 8

Fields of applications

Those systems based on permanence memories can be applied for a wide range of cases in binary image sequence analysis.More specifically, they allow us to obtain information about image elements motion, therefore, we can accomplish vibrations analysis, image segmentation in different direction flow areas, detection of characteristic motion elements, etc..

Systems of this type also offer the possibility to analize sequences for the extraction of information regarding occurrence, which is not always motion related. Moreover, these systems can be useful for noise analysis, study and control of thresholding, performance and an endless list of applications with the possibility of operation in real time.

Limitations : For motion analysis cases, the main obstacle for this type of system can be found in variations in the binarization stage, not related with the image elements motion. There are also some limitations regarding the density of pixels in the scene, since high pixel density implies trail superposition.

Another obvious drawback is that implicit in the sampling of the scene, which obviously limits the motions which can be analized.

Conclusions

Taking into consideration the proposals described above, we believe that the use of systems based on permanence memories provides obvious advantages for the extraction of motion parameters, or occurrence in image sequences. This computational structure simplifies the process in real time.

Acknowledgements:

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