Available online at www.sciencedirect.com
ScienceDirect
Expert Systems with Applications 33 (2007) 955–967
Expert Systems with Applications
www.elsevier.com/locate/eswa

Modelling the Stereovision-Correspondence-Analysis task by Lateral Inhibition in Accumulative Computation problem-solving method

Antonio Fernández-Caballero [a,*], María T. López [a], José Mira [b], Ana E. Delgado [b], José M. López-Valles [c], Miguel A. Fernández [a]

[a] Departamento de Sistemas Informáticos, Escuela Politécnica Superior de Albacete, and Instituto de Investigación en Informática de Albacete, Universidad de Castilla-La Mancha, 02071 Albacete, Spain
[b] Departamento de Inteligencia Artificial, E.T.S. Ingeniería Informática, Universidad Nacional de Educación a Distancia, 28040 Madrid, Spain
[c] Departamento de Telecomunicación, Escuela Universitaria Politécnica de Cuenca, Universidad de Castilla-La Mancha, 13071 Cuenca, Spain

Abstract

Recently, the Algorithmic Lateral Inhibition (ALI) method and the Accumulative Computation (AC) method have proven to be efficient in modelling at the knowledge level for general-motion-detection tasks in video sequences. More precisely, the task of persistent motion detection has been widely expressed by means of the AC method, whereas the ALI method has been used with the objective of moving objects detection, labelling and further tracking. This paper exploits the current knowledge of our research team on the mentioned problem-solving methods to model the Stereovision-Correspondence-Analysis (SCA) task. For this purpose, ALI and AC methods are combined into the Lateral Inhibition in Accumulative Computation (LIAC) method. The four basic subtasks, namely "LIAC 2D Charge-Memory Calculation", "LIAC 2D Charge-Disparity Analysis" and "LIAC 3D Charge-Memory Calculation" in our proposal of SCA are described in detail by inferential CommonKADS schemes. It is shown that the LIAC method may perfectly be used to solve a complex task based on motion information inherent to binocular video sequences.

Keywords: Algorithmic Lateral Inhibition; Accumulative Computation; Lateral Inhibition in Accumulative Computation; Stereovision; Correspondence analysis

1. Modelling the Stereovision-Correspondence-Analysis task

1.1. The Lateral Inhibition in Accumulative Computation method

Recently, the Algorithmic Lateral Inhibition (ALI) method, as well as the Accumulative Computation (AC) method, has proven to be greatly efficient in modelling at the knowledge level for general-motion-detection tasks in video sequences. More precisely, the task of persistent-motion detection has been widely expressed by means of the AC method (Mira, Fernández, López, Delgado, & Fernández-Caballero, 2003), whereas the ALI method has been used with the objective of moving-objects detection (Mira, Delgado, Fernández-Caballero, & Fernández, 2004), labelling and further tracking (López, Fernández-Caballero, Mira, Delgado, & Fernández, 2006). This paper exploits our research team current knowledge on the problem-solving methods mentioned to model the Stereovision-Correspondence-Analysis (SCA) task (López-Valles, Fernández, Fernández-Caballero, & Gómez, 2005). For this purpose, ALI and AC methods are combined into the Lateral Inhibition in Accumulative Computation (LIAC) method (Fernández-Caballero, Fernández, Mira, & Delgado, 2003) as a powerful problem-solving method

* Corresponding author. Tel.: +34 967 599200; fax: +34 967 599224.
E-mail address: caballer@info-ab.uclm.es (A. Fernández-Caballero).

0957-4174/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.eswa.2006.07.009

```
for u=1 to (H_max/2)
  for v=(V_max-1) to 1
    for d=1 to d_max{
```

$$s1 = \max[Se3_{L/R}(u,v,d,t), Se3_{L/R}(u,v+1,d,t)]$$
$$s2 = 0$$
$$Se3_{L/R}(u,v,d,t) = \begin{cases} s1 & \text{if } Sd3_{L/R}(u,v,d,t) = 1 \\ s2 & \text{if } Sd3_{L/R}(u,v,d,t) = 0 \end{cases} \tag{12}$$

```
}
```

4.2. 3D Depth-Memory Calculation

Once we have calculated the region's sizes which each charge Memory correspondence belongs to, we need to associate, as maximum reliability disparity for each pixel, those values whose charge $S3_{L/R}$ (u,v,d,t) is maximal in d. With this, we are imposing the uniqueness restriction, since each processing element will only have a single disparity value as a final value.

This subtask has the *3D Charge-Correspondence Memory* $S3_{L/R}$ (u,v,d,t) as input and the maximum disparity imposed by the disparity restriction as static role. The processing carried out to obtain the disparity associated to each charge element is also shown in the following expression:

$$D3_{L/R}(u,v,t) = i | S3_{L/R}(u,v,i,t) \geqslant S3_{L/R}(u,v,j,t), \quad \forall (i,j), \ 0 \leqslant i,j \leqslant d_{\max} \tag{13}$$

This operation tries, basically, to find the value for i whose $S3_{L/R}(u,v,i,t)$ is maximum in the third dimension. The arrangement restriction is included in the method proposed for the charge-disparity-analysis subtask, since the specific correspondence verification and subsequent region configuration means maintaining the order of the found correspondences.

Based on the charge disparity calculation done and the camera system's geometric analysis, we can estimate the moving elements' depth. With this, we have obtained a stereoscopic motion Memory in which each moving element from the scene appears associated to its depth. Fig. 14 shows a graph of the input and output roles to the *3D Depth-Memory Calculation* subtask.

5. Conclusions

In this paper a combination of the ALI and AC methods into the Lateral Inhibition in Accumulative Computation (LIAC) method is presented as a powerful problem-solving method for the task of correspondence analysis in binocular stereovision. The current work has shown the convenience of modelling knowledge of tasks and methods in terms of a library of reusable components (inferential verbs "evaluate", "compare" and "select") and a set of input and output roles played by the entities of the application domain. For each one of the subtasks the results of the inferential scheme are illustrated.

Up to now, the common stereovision techniques are based on shape, analyzing disparity, and thus obtaining depth based on the system's geometry. However, they are basically static. This article proposes a new alternative which allows the continuous obtaining of three-dimensional information about motion in a scene. The motion trails of several moving objects in each frame will be different to each other due to the different nature of their movements. However, a single moving object will create very similar trails in both permanence memories that make up a stereo pair. This makes the trail-based correspondence analysis simple and robust at the same time.

The solution proposed involves a type of process which tries to take advantage of the use of high-order primitives and pixels only. On the one hand, the elements placed in correspondences are regions obtained from moving objects' motion trails by means of permanence memory interpretation. Again, this enables to obtain simple and robust correspondences. On the other hand, the fact that each pixel can decide, through a local analysis and based on motion trail overlapping, which disparity is more reliable creates a dense disparity memory, which is considered the biggest advantage in pixel-based correspondence systems.

Acknowledgements

This work is supported in part by the Spanish CICYT TIN2004-07661-C02-01 and TIN2004-07661-C02-02 grants, and the Junta de Comunidades de Castilla-La Mancha PBI06-099 grant.

References

Binaghi, E., Gallo, I., Marino, G., & Raspanti, M. (2004). Neural adaptive stereo matching. *Pattern Recognition Letters, 25*, 1743–1758.

Breuker, J., & van de Velde, W. (1994). *CommonKADS library for expertise modelling*. IOS Press.

Brown, M. Z., Burschka, D., & Hager, G. D. (2003). Advances in computational stereo. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 25*(8), 993–1008.

Choi, I., Yoon, J.-G., Lee, Y.-B., & Chien, S. I. (2003). Stereo system for tracking moving object using log-polar transformation and zero disparity filtering. In *Proceedings of the 10th international conference on computer analysis of images and patterns* (pp. 182–189).

Di Stefano, L., Marchionnia, M., & Mattoccia, S. (2004). A fast area-based stereo matching algorithm. *Image and Vision Computing, 22*, 983–1005.

Fernández-Caballero, A., Fernández, M. A., Mira, J., & Delgado, A. E. (2003). Spatio-temporal shape building from image sequences using lateral interaction in accumulative computation. *Pattern Recognition, 36*(5), 1131–1142.

Goulermas, J. Y., & Liatsis, P. (2001). Hybrid symbiotic genetic optimisation for robust edge-based stereo correspondence. *Pattern Recognition, 34*, 2477–2496.

Grimson, W. E. L. (1985). Computational experiments with a feature based stereo algorithm. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 7*, 17–34.

Gutiérrez, S., & Marroquín, J. L. (2004). Robust approach for disparity estimation in stereo vision. *Image and Vision Computing, 22*(3), 183–195.