A CONSTANT FALSE ALARM RATE FOCUS DETECTOR USING 2-D NONCAUSAL AND NONSTATIONARY WNDR MODELING

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One can consider a X-ray photograph or tomogram as a sample of a two-dimensional (2-D) random field represented by a white-noise-driven representation (WNDR)

$$y(i,j)=-\sum_{(k,l)\in N} f_{k,l}\, y(i-k,j-l)+w(i,j) \quad (1)$$

where the N is called neighborset of the representation whose shape determines the model causality. Previously, only causal and stationary WNDRs were fully used for the lack of an efficient parameter estimation technique to estimate the parameters $f_{k,l}$ of the general noncausal WNDR which represents the gray level at one point as a linear combination of its neighbors in all directions and a white noise, and unsatisfactory results were observed. In this paper, we study a constant false alarm rate (CFAR) focus detector using 2-D noncausal WNDR modeling based on an asymptotically consistent and computationally efficient modified least-squares (LS) estimation method recently developed by the authors, for identifying parameters of such a noncausal model (cf. *Preprints, 8th IFAC symposium on Identification and System Parameter Estimation*, Beijing, China, Aug.27-31,1988). Furthermore, the nonstationarity is also assumed in the modeling so that the model parameters should be denoted as $f_{k,l}(i,j)$ rather than simple $f_{k,l}$, for the image statistics of the focuses and the normal parts of organs are different.

Because the modified LS method is for stationary case, we use, in this paper, an adaptive companion of the method developed in our paper presented at the World Congress on Medical Physics and Biomedical Engineering, San Antonio, USA, Aug.6-12, 1988, by carefully exploiting the special structures of the normal equation set of the modified LS method. The adaptive method using only local pixels in a sliding data window is a finite memory algorithm and is spatially recursive in nature, and it estimates the parameters of the noncausal and nonstationary WNDR consistently and computationally efficiently. Both theoretical analyses and computer simulations show that the estimates produced by this method are about 10 times as accurate as those produced by conventional LS, while the computational complexity of the former is only the square root of that of the latter.

In a similar way in which Therrien, Quatieri and Dudgeon did their works (cf. Charles W. Therrien, Thomas F. Quatieri and Dan E. Dudgeon, Statistical Model-Based Algorithms for Image Analysis, *Proceedings of the IEEE*, Vol.74, No.4, pp.532-607, 1986), we Developed a probability density function (PDF) for the photograph based on the noncausal and nonstationary WNDR modeling, made significance testing under the CFAR constraint, and constructed a CFAR focus detector by programming PC VISION image processing system with FORTRAN77 and 8088 assembly language. The CFAR detector can easily detect calculuses in urinary organs, pulmonary diseases and other diseases from the corresponding X-ray photographs, while detectors based on other modeling techniques can not. The details about the structure of the CFAR detector and of some experiments will be given during the presentation.

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