the ITU-R model. Therefore, we suggest that the worst-month relation in eqn. 3 with the recommended values $Q_1 = 1.32$ and $\beta = 0.27$ can be used in the Malaysian environment.

Table 1: Measured values for Q_1 and β in Malaysia

	Q_1	β
UTM-KL	1.22	0.28
UTM-Skudai	1.42	0.25
USM-SMV	1.37	0.26
Average	1.32	0.27

Conclusion: The worst-month statistics on rainfall rate are very useful in designing high quality communication networks since the maximum occurrence of events that lead to the degradation of the network is expected to be higher in the worst month. It is experimentally verified that the power law relation in eqn. 3 with the ITU-R recommended values for Q_1 and β can safely be used for estimating the worst-month statistics in Malaysia. New values for the parameters Q_1 and β are proposed in order to obtain a better estimate for the worst-month statistics in Malaysia.

Acknowledgments: The authors wish to thank the University of Technology Malaysia and Cellular Communication Network (M) Sdn. Bhd. for supporting the research. They also thank S.I.S. Hassen and Lee Leong Hoong for providing the USM data.

24 June 1999
Electronics Letters Online No: 19990936
DOI: 10.1049/el:19990936

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Accurate analytical model for MPEG coded video traffic

H. Liu, N. Ansari and Y.Q. Shi

Self-similar processes, modulated according to the MPEG GOP (group of pictures) structure, are proposed to accurately capture both the SRD (short range dependency) and LRD (long range dependency) of MPEG video traffic.

Introduction: Traffic generated by video applications is increasingly cramming existing networks, and it is thus essential to accurately characterise video traffic for efficient network management. Traditional models, however, fall short in describing video traffic which is strongly autocorrelated and bursty [1]. Hence, autocorrelations among data should be taken into consideration.

The empirical data used here was MPEG coded data for the film Star Wars [Note 1]. The frames were organised as follows: IBBPBBPBBPBB IBBPBB..., i.e. 12 frames in a group of pictures (GOP). I, P, and B frames were compressed by different techniques. It is clear that the autocorrelation function (ACF) of the MPEG coded video, shown in Fig. 1, can hardly be captured by a simple random process.

Modelling MPEG coded data: The MPEG coded data are first decomposed into 10 subsequences X_I, X_P, X_{B1}, X_{B2}, ..., and X_{B8}. X_I consists of all I frames, X_P all P frames, X_{B1} the first B frames in all GOPs, X_{B2} the second B frames in all GOPs, and so on. We have used $k^{-\beta}$, $e^{-\beta k}$ and $e^{-\beta\sqrt{k}}$ (k is the lag between frames, and β is a constant), corresponding to the ACFs of a self-similar process [2], a Markov process, and an $M/G/\infty$ input process [3], respectively, to approximate the ACFs of these subsequences. Self-similar processes were found to provide the best approximations. For illustrative purposes, approximations for P and B_1 are shown in Figs. 2 and 3, respectively.

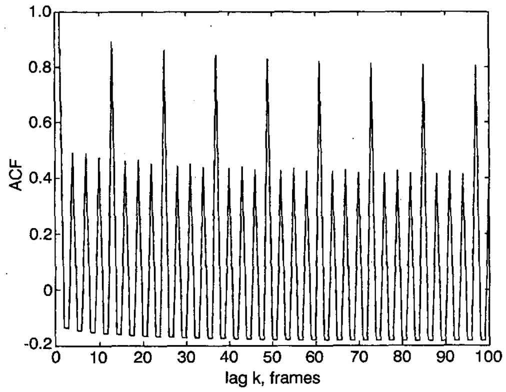

Fig. 1 *ACF of MPEG compressed video of Star Wars*

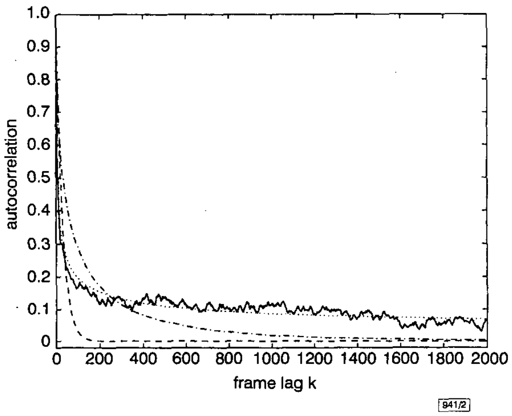

Fig. 2 *Approximation for ACF of P frames*

·········· self-similar process
——— empirical trace
· – · – · M/G/infinity
– – – – Markov process

Using the least squares method, β = 0.4663, 0.3546, 0.4468, 0.4779, 0.4294, 0.4656, 0.4380, 0.4682, 0.4465, and 0.4606 are obtained for X_I, X_P, X_{B1}, X_{B2}, ..., and X_{B8}, respectively. The corresponding Hurst parameters ($H = 1-\beta/2$) for these processes are H = 0.7668, 0.8227, 0.7766, 0.7610, 0.7853, 0.7672, 0.7810, 0.7659, 0.7768, and 0.7697, respectively.

Marginal distributions of these subsequences are modelled by Beta distributions which have the following form of probability density function:

$$f(x;\gamma,\eta,\mu_0,\mu_1) = \begin{cases} \frac{1}{\mu_1-\mu_0}\frac{\Gamma(\gamma+\eta)}{\Gamma(\gamma)\Gamma(\eta)}\left(\frac{x-\mu_0}{\mu_1-\mu_0}\right)^{\gamma-1}\left(1-\frac{x-\mu_0}{\mu_1-\mu_0}\right)^{\eta-1} & \\ \qquad\qquad \mu_0 \le x \le \mu_1, 0 < \gamma, 0 < \eta & \\ 0 \qquad\qquad \text{otherwise} & \end{cases} \quad (1)$$

where γ and η are the shape parameters, and $[\mu_0, \mu_1]$ is the domain where the distribution is defined. Using the formulas introduced in [4], the estimated shape parameters η = 1.5237, 1.5699, 1.4172, 1.3016, 1.6858, 1.6329, 1.7276, 1.4218, 4.0585, 1.5402, and γ = 12.7263, 11.1939, 8.1089, 8.1604, 11.8499, 13.9278, 12.2180, 8.6536, 10.4233, 11.1768 are obtained for X_I, X_P, X_{B1}, X_{B2}, ..., and X_{B8}, respectively.

Note 1: The MPEG coded data were courtesy of M.W. Garrett of Bellcore and M. Vetterli of UC Berkeley.

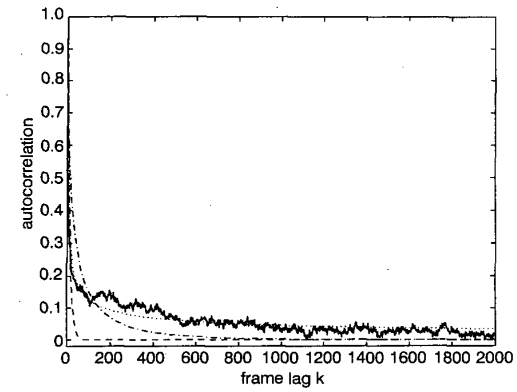

Fig. 3 *Approximation for ACF of B_I frames*

·········· self-similar process
——— empirical trace
· — · — · M/G/infinity
– – – – Markov process

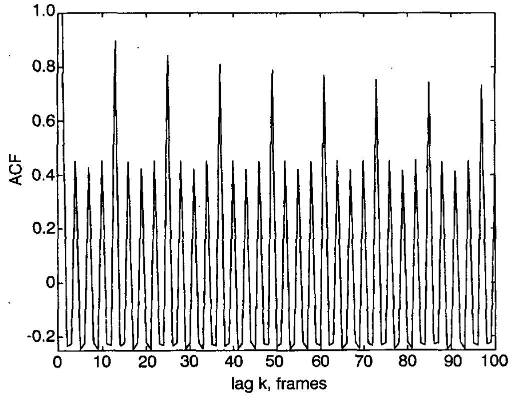

Fig. 4 *ACF of traffic data generated by our model*

Sequentially modulating the self-similar processes (estimated from the subsequences) in an order similar to the GOP pattern results in a random process, a rather accurate model for the MPEG coded traffic. The ACF of the traffic generated by our model shown in Fig. 4 is very close to that of the real data trace for both small and large lag (k), implying that our model can capture both SRD and LRD.

Acknowledgment: This work was carried out in part while N. Ansari was on leave at the Chinese University of Hong Kong, and Y.Q. Shi on leave at the Nanyang Technical University of Singapore.

29 June 1999
Electronics Letters Online No: 19990931
DOI: 10.1049/el:19990931

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Isotropic masks make efficient linear feature detectors

E.R. Davies

It is shown that isotropic masks can be used for the efficient detection of linear features in digital images. Early tests have shown useful performance when applied to the task of locating insects in grain. This work should also be valuable in other applications where line features have to be located, and also those where thin lines have to be tracked, such as document interpretation and PCB inspection.

Introduction: Line segment detection is an important task in image analysis. In real-time applications such as automated visual inspection it must be carried out both effectively and efficiently. In this Letter a novel approach to this problem is proposed. For simplicity we start by considering how to design line segment detectors for 3 x 3 windows; we then generalise the results to the larger windows that might be used in practical applications.

A conventional template matching approach would lead to masks such as the following for detecting lines of single pixel width:

$$\begin{bmatrix} -1 & -1 & -1 \\ 2 & 2 & 2 \\ -1 & -1 & -1 \end{bmatrix} \quad \begin{bmatrix} -1 & -1 & 2 \\ -1 & 2 & -1 \\ 2 & -1 & -1 \end{bmatrix}$$

In general, eight masks are required to locate features in all possible orientations [1], but in this case only four masks are required as line segments have 180° rotational symmetry. Nevertheless, it would be useful if the degree of computation could be reduced by cutting down the number of masks required to be below four. This problem was tackled in [2] and it was found that the vector approach used in edge detection operators such as the Sobel operator could also be used for line segment detection. The solution involved the use of quadrature masks which act at 45° rather than 90° to each other: these were able to cope with all possible line segment orientations because of the 180° rotational symmetry possessed by line segments. As a result, the amount of computation for line segment detection was approximately halved. Here we consider an alternative approach with the potential for further reduction in the amount of computation, which results from using a single mask for the purpose. Such a mask would have an isotropic response, and in a 3 x 3 window would take the form

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

Such a mask should be viable, as it would give a signal equal to 8–1–1 = 6 when applied to a line segment of unit width and unit strength, whatever its orientation.

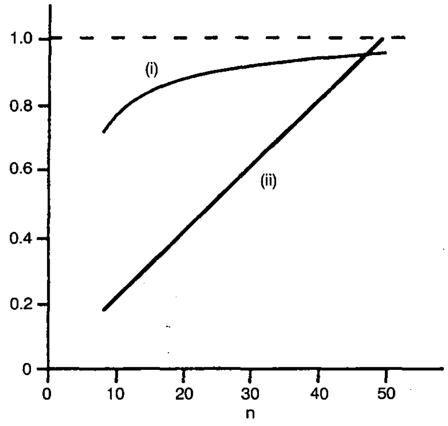

Fig. 1 *Graphs showing the tradeoff between SNR and computational load for isotropic masks*

(i) σ
(ii) $\nu/50$