Our numerical simulations clearly indicate that the modified ICCG method[6] fails to converge as the A matrix becomes highly asymmetric and its eigenvalues become smaller and smaller. On the contrary, the generalised ICCG method always converges to a solution.

In view of the fact that q_i is generated from the r_i vector through multiplications of A' and the inverse of incomplete decomposition, one may conjecture that q_i does not need to be generated at all. Indeed, it has been verified through numerical simulations that, by replacing q_i with r_i and replacing $A(LL')^{-1}$ by the identity matrix during the first few iterations, the gen- [illegible] illustrated in [illegible] the entire [illegible] to lead to the convergent solution.

[illegible] June 1982

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IMAGE TRANSMISSION THROUGH A SINGLE OPTICAL FIBRE BY COLOUR CODING

Indexing terms: Optical fibres, Image transmission

Two-dimensional image transmission through a single multimode fibre has been performed using colour coding. The correspondence between image points and colours is achieved with the combination of dispersive prisms and fibre bundle convertors. The light source is an ordinary tungsten lamp. The reconstructed 10 × 10 image can be seen by the naked eye.

Introduction: Direct two-dimensional image transmission through a single multimode fibre, i.e. without electronic scanning, is possible. A number of proposals have been made: Selfoc fibre,[1] rectangular guide,[2] phase conjugation[3] and temporal coding.[4] We consider here the coding technique discussed in References 5 and 6. They differ in the way that the second dimension is transmitted. Mechanical scanning,[5] which is slow, modal coding,[7] which suffers from mode coupling in the fibre, or crossed dispersions[6,8] are used.

In the work presented here, we use colour coding and a single multimode transmission fibre, but image-to-spectrum and spectrum-to-image conversions at the output ends of the fibre are performed with a fibre bundle convertor (called an image dissector in Reference 9). This new technique is capable of distortionless bidimensional image transmission and does not suffer from either mode coupling or chromatic dispersion of the fibre used until the transmission rate reaches extremely high values.

Set-up and operation: The set-up is shown in Fig. 1. In the experiment, two fibre bundle convertors are used for the conversion of a square format into a linear array. These convertors consist of a bundle of 10 × 10 optical fibres with 250 μm core diameter (Fig. 2) converted into a linear 100-fibre array.

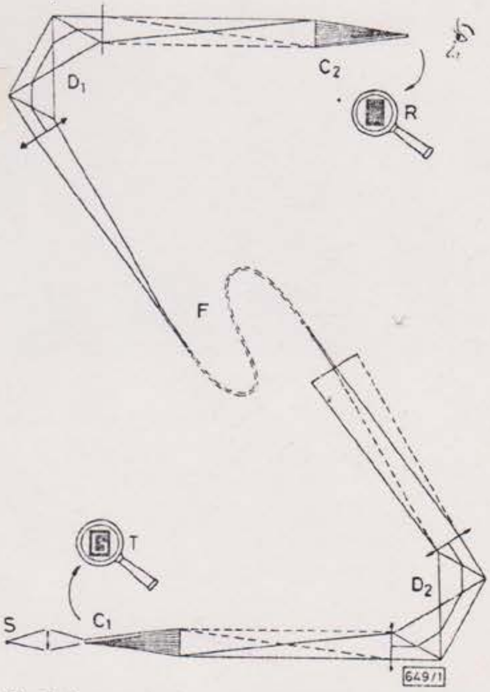

Fig. 1 *Experimental set-up for image transmission through a single multimode optical fibre by colour coding*

S: Source, a tungsten lamp
F: Transmission fibre
T: Image to be transmitted
R: Received image
D_1, D_2: Dispersion prims
C_1, C_2: Square-to-linear convertors

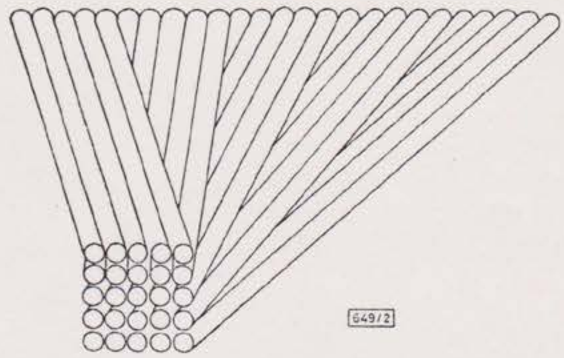

Fig. 2 *Fibre optic square-to-linear format convertor*

An autoemissive coherent object, or a transparency, is imaged on the convertor (2·5 mm × 2·5 mm). Each fibre of the convertor acts as a secondary source. The beam then passes through a dispersive device D_1 (a couple of highly dispersive flint prisms).

The spectra given by the 100-fibre output ends partially overlap in the spectrum plane of D_1, giving rise to a composite spectrum, referred to as an 'image spectrogram' in Reference 10.

In order to transit the image, the input end of the transmission fibre is placed at the centre of this image spectrogram. At the output end of the transmission fibre, a second dispersive device D_2, identical to the input one, displays the coded spectrum on the linear end of convertor C_2. The transmitted image can be seen with the naked eye through a lens focused at the square end face of convertor C_2.

Note that a power-loss factor $1/N$ is suffered at the input end of the transmission fibre, where N is the number of image elements to be transmitted. However, the colour-coded information can be transmitted to many different users, without suffering any further optical loss, by setting in the image spectrogram plane the input end of several transmission fibres.

Results: Fig. 3 shows the results obtained in transmitting some characters given at the input end of the system in the form of $2{\cdot}5 \times 2{\cdot}5$ mm transparencies. Each character was transmitted one at time. Owing to difficulties in the fibre

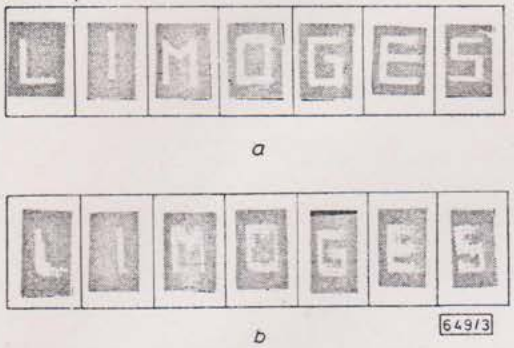

Fig. 3 *Experimental results*

a Transmitted image
b Received image

bundle convertor 10×10 square matrix handicraft, the received images look a little wavy. Another defect to note there is the anisotropic crosstalk between the neighbouring spectral channels that enlarges the nonvertical parts of the characters. The cladding of the plastic fibres used in the convertor construction is very thin (a few micrometres). Thus the fibre cores are almost jointed together in the convertors, giving rise to some spectral channel overlapping. This drawback can be removed by increasing the spacing of the fibre axes to two core diameters at the linear array end of the convertors. But, in that case, of course, the power-loss ratio at the transmission fibre input becomes $1/2N$ (-23 dB for a 10×10 image transmission).

Conclusion: Our experiment has shown that it is possible to transmit an autoemissive and incoherent image of 10×10 resolution points through a single multimode optical fibre by means of colour coding.

Experiments have been carried out with prisms, but a more compact and more dispersive system can be built with blazed reflection gratings in a Littrow mount.

The technique reported here seems to be most suitable for the broadcasting of alphanumeric characters at high speed. With present-day low-loss fibres, the images can be transmitted over many kilometres without significant loss of intensity.

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