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Fleet et al.

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[54] **AUTOMATIC GEOMETRIC IMAGE TRANSFORMATIONS USING EMBEDDED SIGNALS**

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[21] Appl. No.: **08/956,839**

[22] Filed: **Oct. 23, 1997**

[51] **Int. Cl.**[6] **G06K 7/12**

[52] **U.S. Cl.** **235/469**; 235/454; 235/462.41; 235/494; 382/165

[58] **Field of Search** 235/469, 462.01, 235/462.04, 462.07, 462.1, 462.125, 462.127, 462.41, 454, 470, 487, 494; 382/164, 165, 309

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,120,045	10/1978	Moellgaard et al.	235/470 X
4,964,066	10/1990	Yamane et al.	235/454 X
5,091,966	2/1992	Bloomberg et al.	382/21
5,199,081	3/1993	Saito et al.	235/380 X
5,278,400	1/1994	Appel	235/494
5,315,098	5/1994	Tow	235/494
5,416,308	5/1995	Hood et al.	235/454
5,629,990	5/1997	Tsuji et al.	235/454 X
5,646,388	7/1997	D'Entremont et al.	235/380

FOREIGN PATENT DOCUMENTS

WO 95/14289	5/1995	WIPO .

OTHER PUBLICATIONS

Brassil et al., "Electronic Marking and Identification Techniques to Discourage Document Copying" in *IEEE Journal on Selected Areas in Communications*, vol. 12, No. 8, Oct. 1995, pp. 1495–1504.

Cox, Kilian, Leighton and Shamoon, "Secure Spread Spectrum Watermarking for Multimedia," *NEC Research Institute Technical Report* No. 95–10, 1995. month missing.

A. Poirson and B. Wandell, "The appearance of colored patterns: pattern–color separability", *Journal of the Optical Society of America A*, 10:2458–2471, 1993. month missing.

A. Poirson and B. Wandell, "Pattern–color separable pathways predict sensitivity to single colored patterns", *Vision Research,* 36:515–526, 1996. month missing.

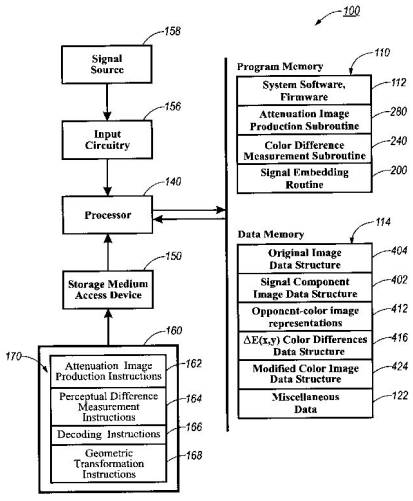
X. Zhang and B. Wandell, "A spatial extension of CIELAB for digital color image reproduction", *Proceedings of the Society of Information Display 96 Digest,* pp. 731–734, San Diego, 1996. month missing.

Primary Examiner—Michael G. Lee

[57] **ABSTRACT**

An acquired (e.g., scanned) image contains an imperceptible periodic signal component (e.g., a sinusoid), decoding of which can be used to automatically determine a linear geometric relationship between the acquired image and the original image in which the signal was embedded, without having the original image available during the decoding process. This known geometric relationship allows for linear geometric properties of the acquired image, such as alignment and scaling, to be automatically matched with those of the original image so that the acquired image may be automatically oriented and scaled to the size of the original image. The embedded periodic signals produce a distinct pattern of local peak power concentrations in a spatial frequency amplitude spectrum of the acquired image. Using geometric constraint information about the embedded signals when the signals were originally embedded in the image, the locations and spatial frequencies of the signals are decoded from the image, providing a linear mapping between the peak power concentrations of the acquired and original image spatial frequency amplitude spectra. This linear mapping can be used to compute the linear geometric relationship between the two images. In an illustrated embodiment, the acquired image contains a set of sinusoidal signals that act as a grid. Decoding of the sinusoids does not require the original image, only information about the predetermined geometric relationship of the embedded sinusoids.

18 Claims, 11 Drawing Sheets



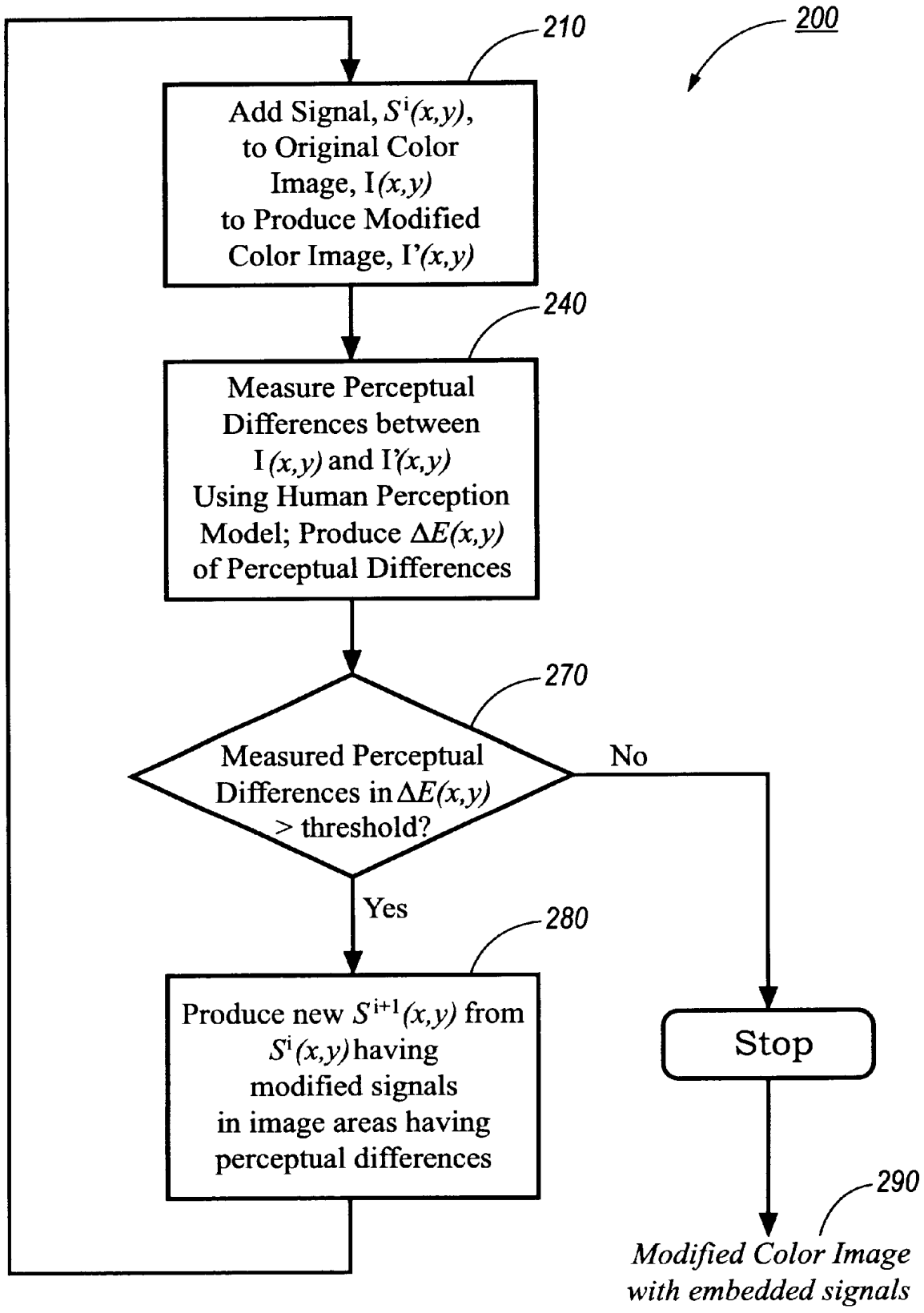
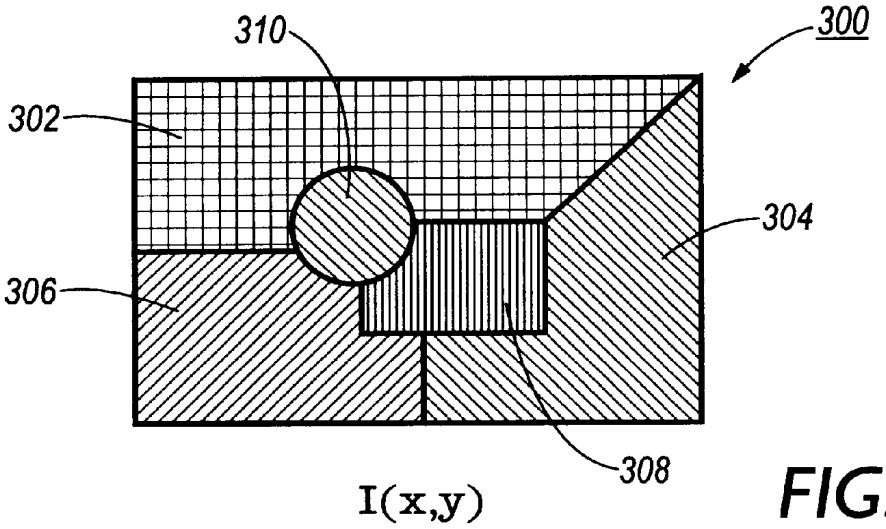
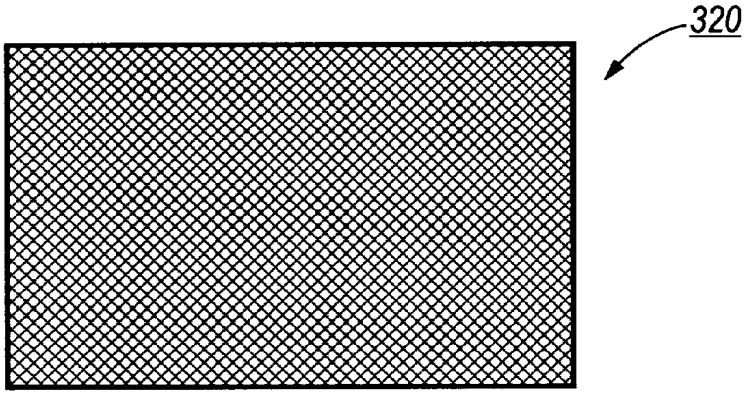


FIG. 1



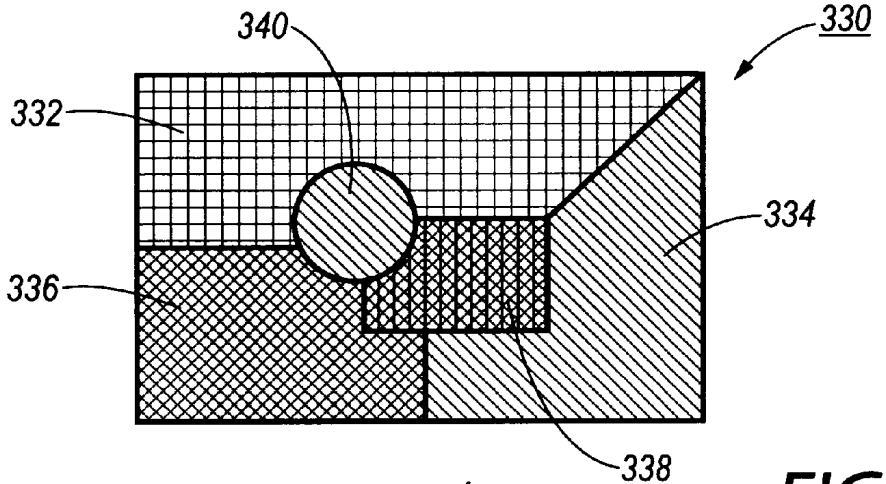
I(x,y)

FIG. 2



$S^i(x,y)$

FIG. 3



$I(x,y)+S^i(x,y)$

FIG. 4

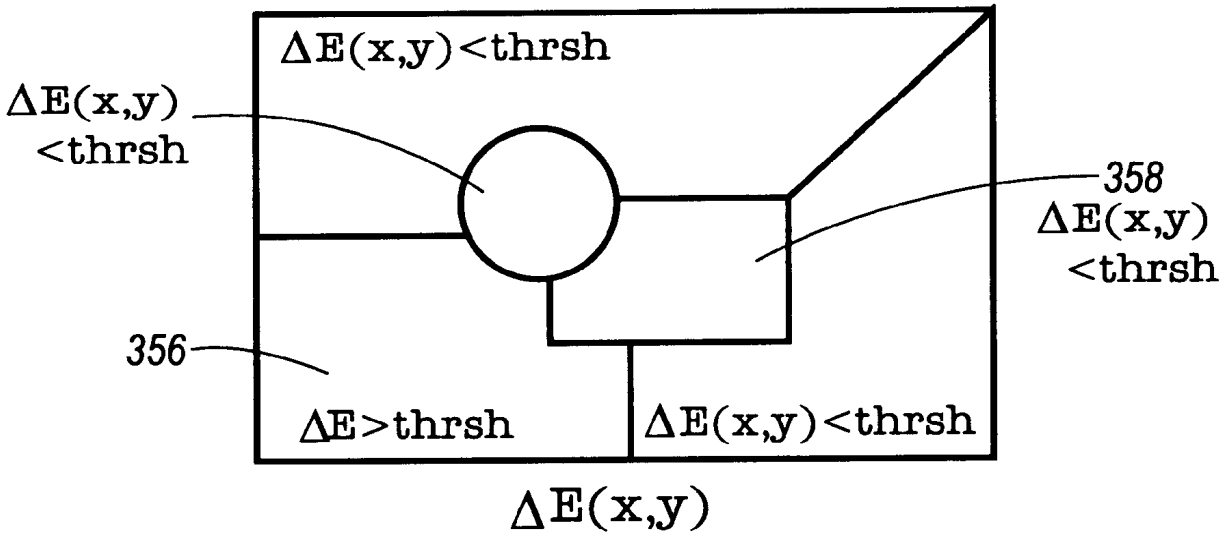


FIG. 5

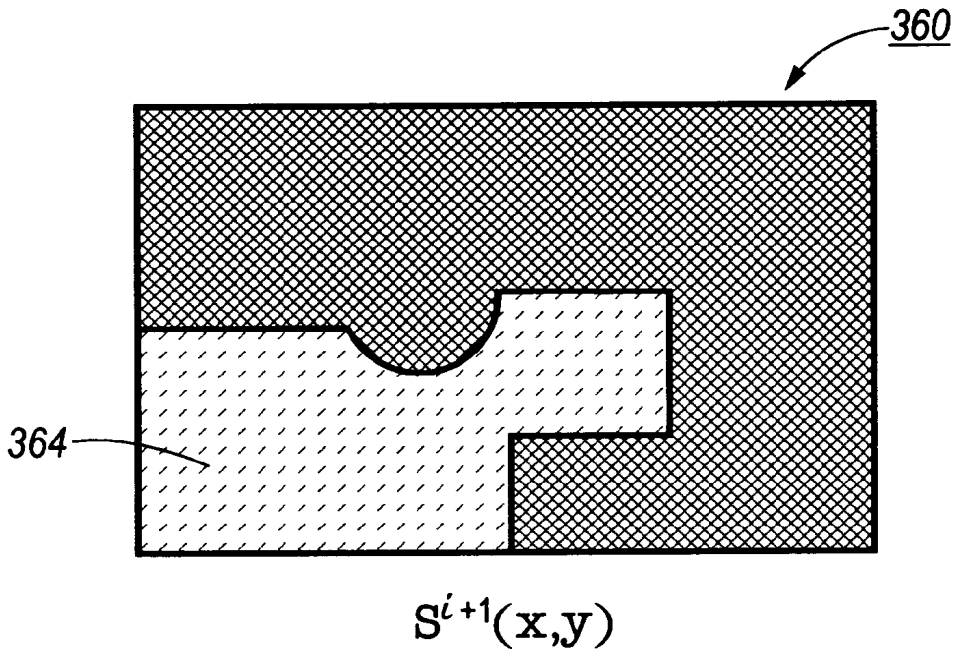


FIG. 6

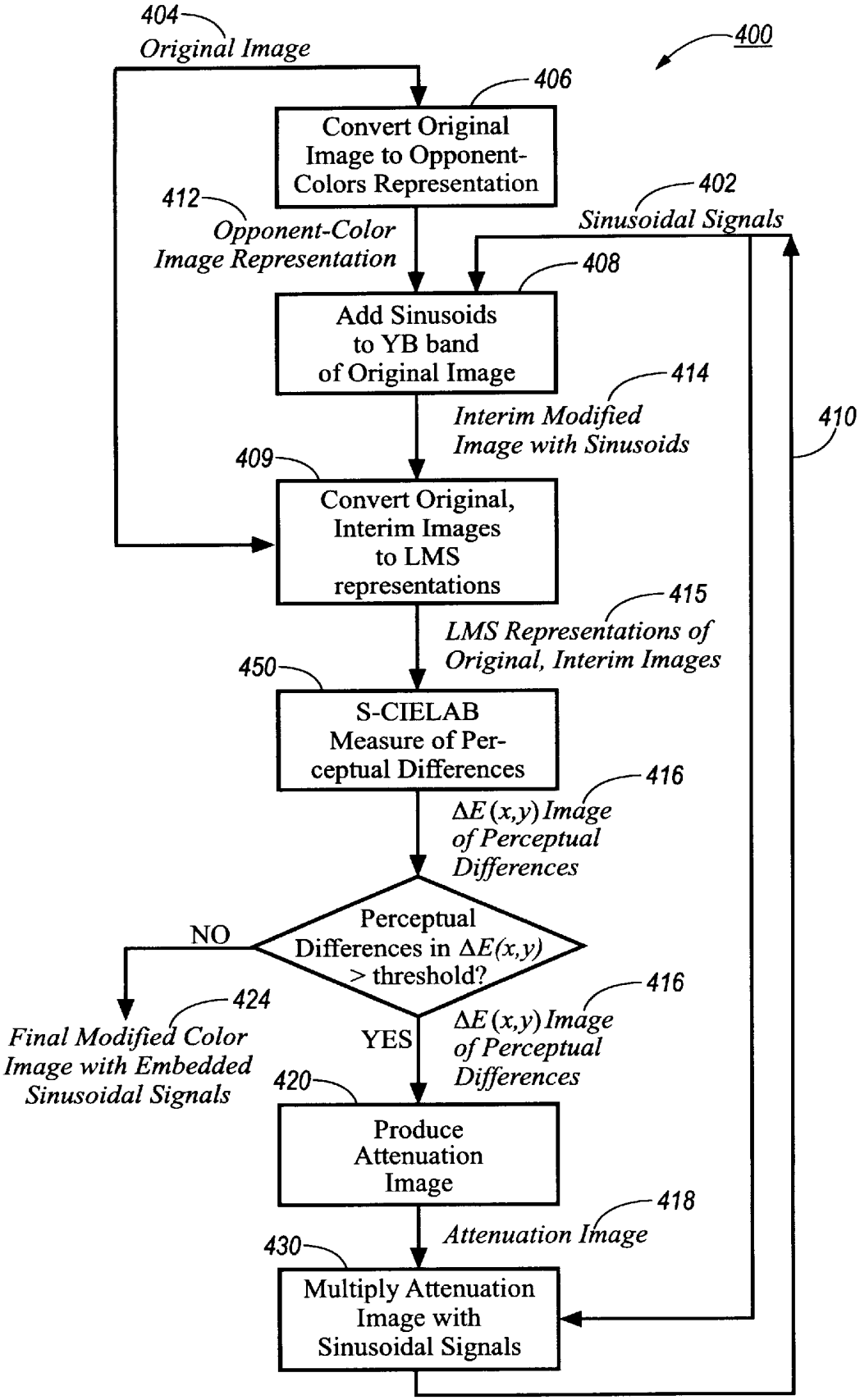


FIG. 7

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