

Exhibit M

- [54] METHOD AND SYSTEM FOR DETECTING ELLIPTICAL OBJECTS
- [75] Inventors: Hideo Tsukune, Kashiwa; Keisuke Goto, Tokyo, both of Japan
- [73] Assignees: Michio Kawata, Director-General of Agency of Industrial Science and Technology; Kabushiki Kaisha Meidensha, both of Japan
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- [22] Filed: Jan. 19, 1984
- [30] Foreign Application Priority Data
Jan. 21, 1983 [JP] Japan 58-8156
- [51] Int. Cl.⁴ G06K 9/46
- [52] U.S. Cl. 382/25; 382/18; 382/41; 382/22
- [58] Field of Search 382/18, 22, 25, 41; 364/725, 721

Attorney, Agent, or Firm—Lowe, Price, LeBlanc, Becker & Shur

[57] ABSTRACT

In order to define the contour of an ellipse, it is necessary to determine five unknown parameters in the general equation representative of centered conics. When directly applying Hough transformation method to the above equation, since a five-dimensional space is required, it is practically impossible to detect an ellipse because a long processing time and a great amount of memory capacity are inevitably required. To overcome these problems, the geometric properties of an ellipse are determined separately on three parameter sub-spaces obtained on the basis of edge vector field: two-dimensional center histogram and two-dimensional (H, B) histogram, one-dimensional C histogram. A peak value on the center histogram represents a group of ellipses having the same center locations; a peak value on the (H, B) histogram represents a group of concentric ellipse having the same eccentricity and axis slope; a peak value on the C histogram defines a single ellipse. By sequentially selecting these peaks in the three sub-spaces, it is possible to define geometric properties of an ellipse under practical processing conditions. In order to define a plurality of ellipses efficiently, several novel methods have been adopted: separation of the rotation directions of edge vector field, recovery of edge vectors having no mate edge vectors; adoption of least mean square method, etc., in particular.

- [56] References Cited
- U.S. PATENT DOCUMENTS
- 3,936,800 2/1976 Ejiri et al. 382/18

OTHER PUBLICATIONS

"Detection of Ellipses by a Modified Hough Transform", by Tsuji and Matsumoto, *IEEE Transactions on Computers*, C 27-8, (1978).

Primary Examiner—Leo H. Boudreau
Assistant Examiner—Jacqueline Todd

18 Claims, 18 Drawing Figures

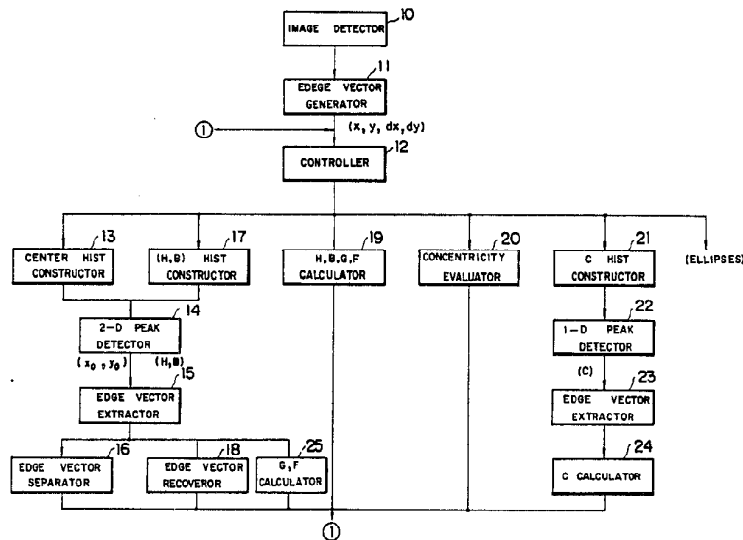


FIG. 1

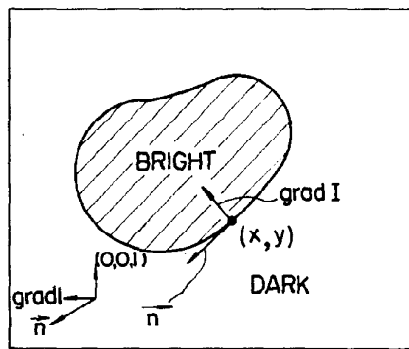


FIG. 2a

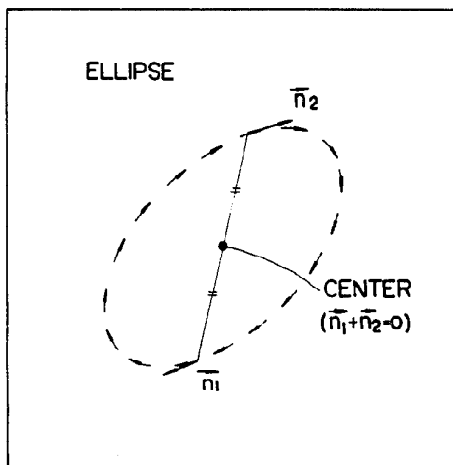


FIG. 2b

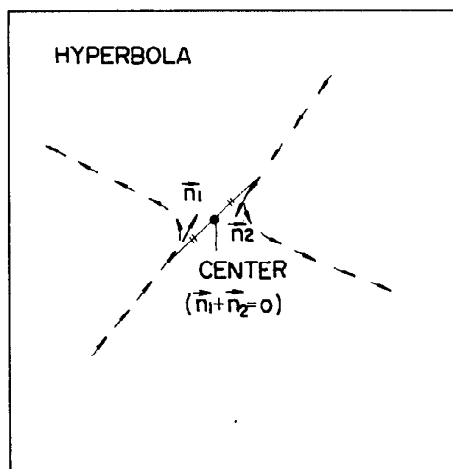


FIG. 2c

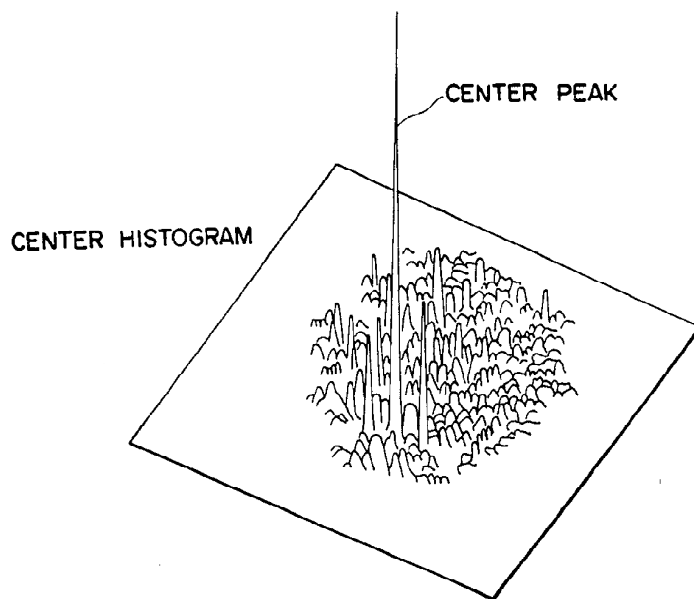


FIG. 3a

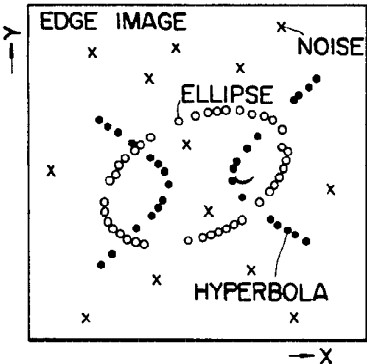


FIG. 3b

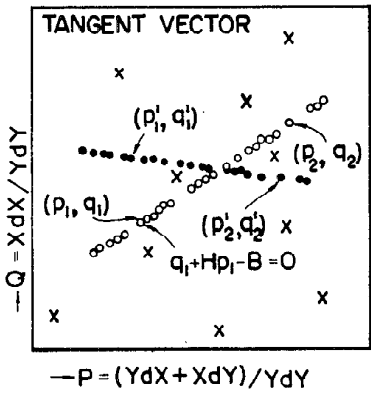


FIG. 3c

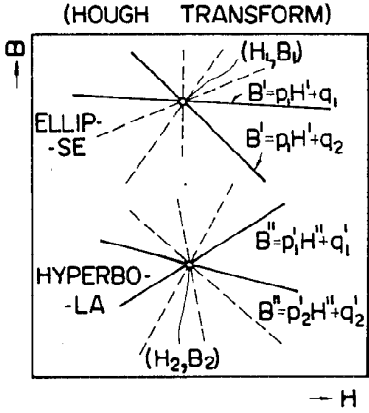


FIG. 3d

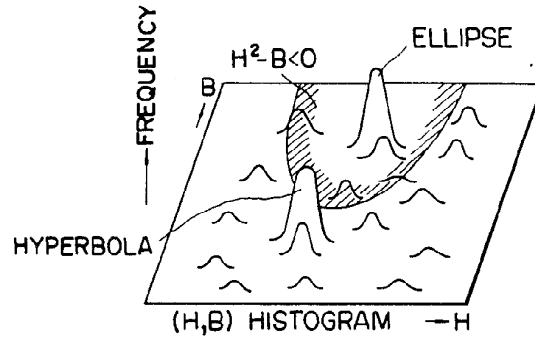


FIG. 3f

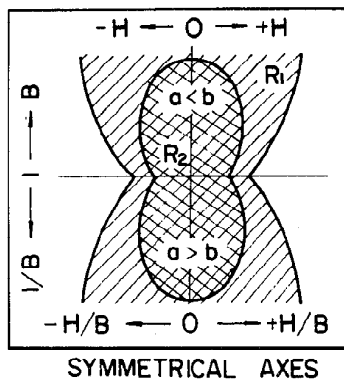


FIG. 3e

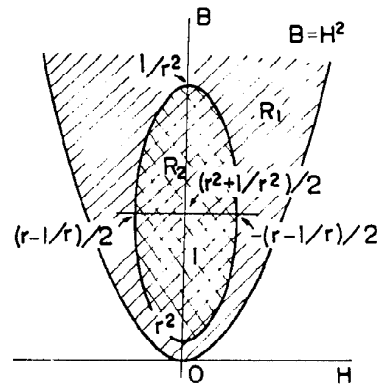


FIG. 4a

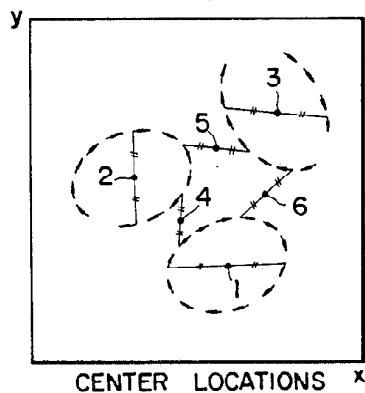


FIG. 4b

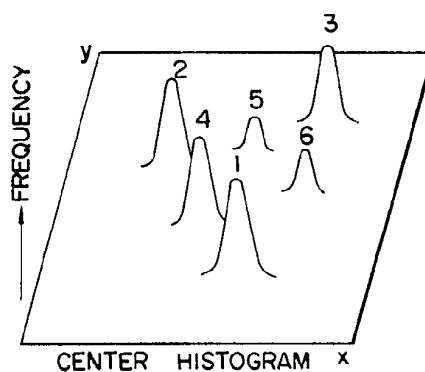


FIG. 5a

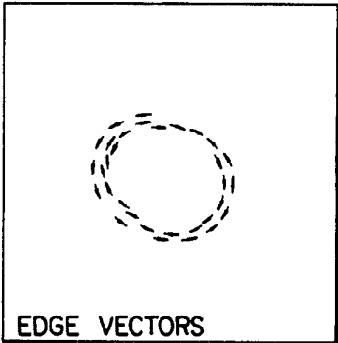


FIG. 5b

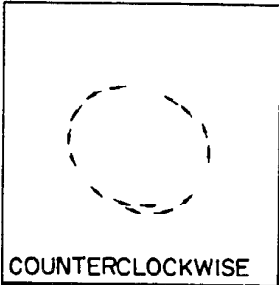


FIG. 5c

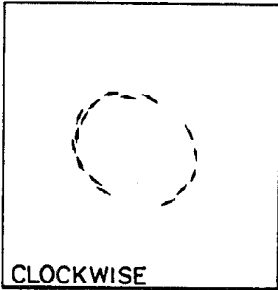


FIG. 6

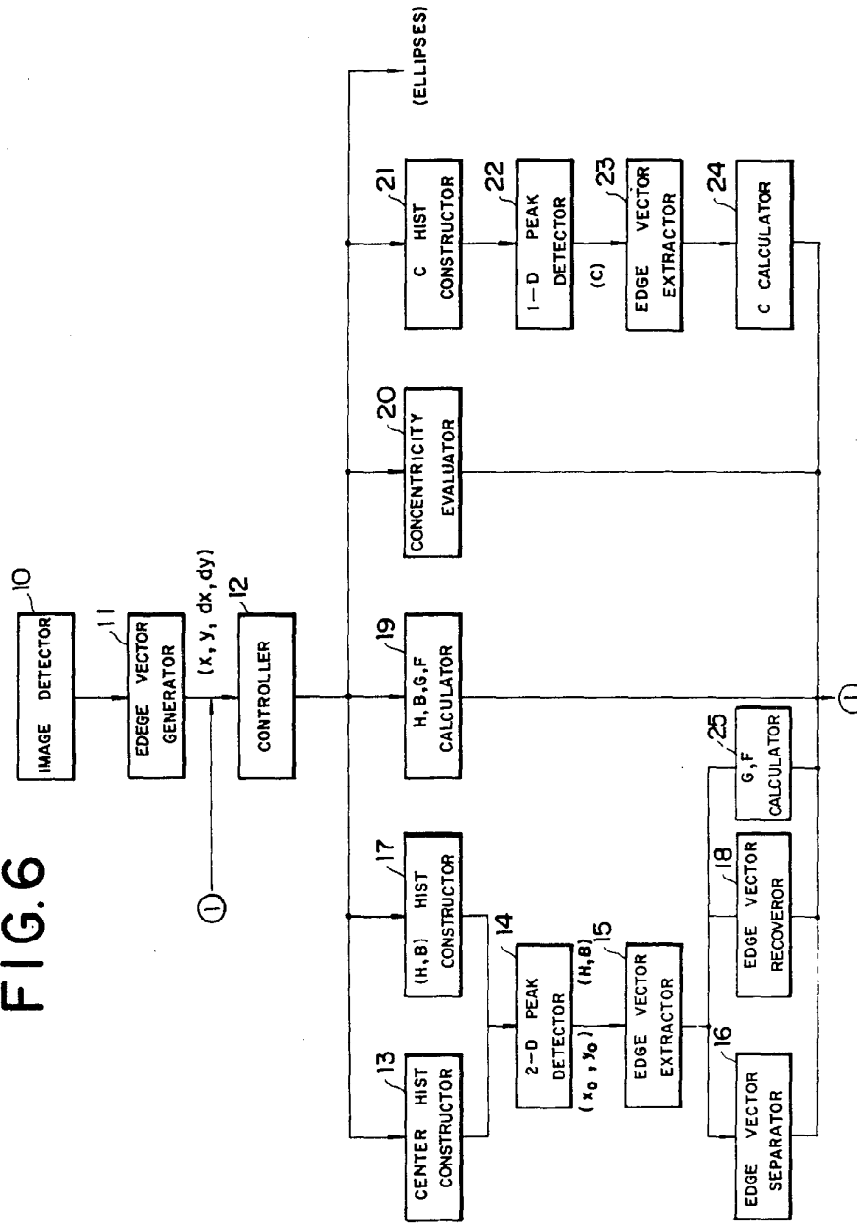


FIG. 7a

