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Remote-Sensing Sunspot Images to Obtain the Sunspot Roads

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***Abstract*—**A combination of image fusion and quad tree decomposition method is used for detecting the sunspot trajectories in each month and computation of the latitudes of these trajectories in each solar hemisphere. Daily solar images taken with SOHO satellite are fused for each month and the result of fused image is decomposed with Quad Tree decomposition method in order to classifying the sunspot trajectories and then to achieve the precise information about latitudes of sunspot trajectories. Also with fusion we deduce some physical remarkable conclusions about sun magnetic fields behavior. Using quad tree decomposition we give information about the region on sun surface and the space angle that tremendous flares and hot plasma gases permeate interplanetary space and attack to satellites and human technical systems. Here sunspot images in June, July and August 2001 are used for studying and give a method to compute the latitude of sunspot trajectories in each month with sunspot images.

***Keywords*—**Quad Tree Decomposition, Sunspot.

I. Introduction

UNDERSTANDING how our Sun works, it helps to imagine that the inside of the Sun is made up of different layers, one inside the other. The core, or the center of the Sun, is the region where the energy of the Sun is produced. The Sun's energy, which is produced in the core, travels outwards. The energy travels first through the radiative zone, where particles of light (photons) carry the energy. It actually takes millions of years for a photon to move to the next layer, the convection zone . At the convection zone energy is transferred more rapidly. This time it is the motion of the gases in the Sun that transfers the energy outwards. The gas at this layer mixes and bubbles, like the motion in a pot of boiling water, this bubbling effect is seen on the surface of the Sun and is called granulation. The three layers of solar interior is depicted in figure1-a. Sunspots appear as dark spots on the surface of the Sun. Temperatures in the dark centers of sunspots drop to about 3700 K (compared to 5700 K for the surrounding photosphere[1]). They typically last for several days, although very large ones may live for several weeks. Sunspots are magnetic regions on the Sun with magnetic field strengths thousands of times stronger than the Earth's magnetic field. Sunspots usually come in groups with two sets of spots. One set will have positive or north magnetic field while the other set will have negative or south magnetic field. The field is strongest in the darker parts of the sunspots - the umbra. The field is weaker and more horizontal in the lighter part - the penumbra. In Fig. 1(b), the sunspot on photosphere is shown. Sunspots rotate around the sun each 27-day or monthly and their paths are like a belt around the sun sphere. In sunspots there is more intense magnetic fields, and as a result due to extra heating of plasmas on proximity of this region and then cause the Magneto Hydrodynamic instability in this regions and as a result cause to solar flares and solar loops near of this region (Fig. 1(a)), also some heated plasmas detached from sun and go to interplanetary space and have an energy approximately equivalent to 100 ton TNT explosion with tremendous explosion , this very heated and ionized gases in plasmasphere and magnetoheat region lead to electromagnetic instability and finally lead to geomagnetic storms near the magnetosheat [6] as is shown in figure1-c and this disturb and harm satellites and very technical systems. A very tremendous explosion occurs in 14 March 1989 that causes the power black-out in Quebec and North America and lead to about 20 million dollar financial damages because of burning of several power transformers due to unexpected extra induced current that geomagnetic disturbance did that, and also 2 million people without electricity energy for about and 100MW power losses. Although sunspots themselves produce only minor effects on solar emissions, the magnetic activity that accompanies the sunspots can produce dramatic changes in the ultraviolet and soft x-ray emission levels. These changes over the solar cycle have important consequences for the Earth's upper atmosphere and also for global climate of the earth. Some researchers based on magnetic map of solar have shown that small changes of solar magnetic fields have major effects on coronal heating [4] that such phenomenon indicating on chaotic behavior of solar interior. Using advanced innovative methods could help scientist for further understanding about the behavior and laws of solar system. Based on image processing methods some physicists compute and functionalize the latitudinal solar wind speed as a function of magnetic observations with the aim of solar images [5].

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[1] The photosphere is the visible surface of the Sun.

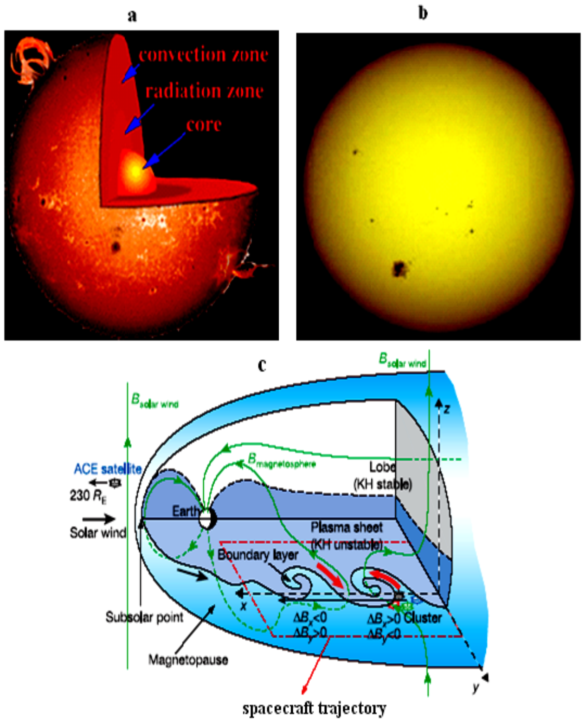

Fig. 1 (a) solar interior and some flares on it, (b) sunspots on photosphere and (c) solar geomagnetic storm that permeate earth magnetosphere and finally lead to geomagnetic disturbance storm in this region and on the earth. Permeation of plasma to magnetosphere could be analyses by Kelvin-Helmholtz Instability (KHI) refre to [6] for more clear information about the process illustrated here

II. Image Fusion Method

All The Fusion method is based on the minimum value selection of pixel (i,j) of image 1 and image 2:

$$P_{i.j}^{Fused} = \min(P_{i,j}^{image\ 1}, P_{i,j}^{image\ 2})$$

Where $P_{i,j}^{Fused}$ denoted the value of pixel at coordinate (i,j) of fused images. The fused images is a color image that in each coordinate, the darker pixel between the same-coordinate pixels of two images would be selected as the fused pixel. This fusion method is illustrated for two color images in Fig. 2.

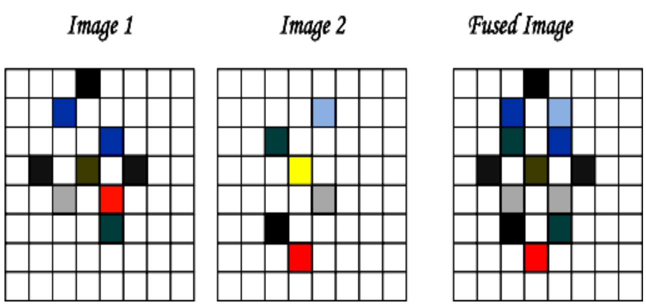

Fig. 2 Block Diagram of fusion method for fusion of two images based on equation 1

III. Quad Tree Decomposition Method

Quad tree decomposition is an analysis technique that involves subdividing an image into blocks that are more homogeneous than the image itself. This technique reveals information about the structure of the image. Some researchers had contribution of using quadtree decomposition method for robot motion planning [2], and also this method had successfully applied for image modeling and for inverse modeling problems [3]. The quadtree is constructed by recursively decomposing the image into four equal-sized quadrants in top-down fashion. Given an $N \times N$ image (N = 2d for some d), the quadtree representation of it is a tree of degree four which can be defined as follows. The root node of the tree represents the whole image. If the whole image has only one color, we label that root node with that color and stop; otherwise, we add four children to the root node, representing the four quadrants of the image. Recursively we apply this process for each of the four nodes, respectively. If a block has a constant color, then its corresponding node is a leaf node; otherwise, its node has four children. Recently, Lee and Horng et al. [1] addressed a constant time quadtree building algorithm for a given image based on a specified space-filling order. Let the data structure of a quadtree node consist of four fields r; c; I and S_z, respectively. The row and column coordinates of the top-left corner of a quadtree node are represented by r and c, the image color of it is represented by I and S_z represents the index of the block size of a quadtree node; if the block size is 4^s then S_z is s. For a binary image, the third field I can be omitted. In Fig. 3, two-step of quad tree decomposition algorithm is depicted.

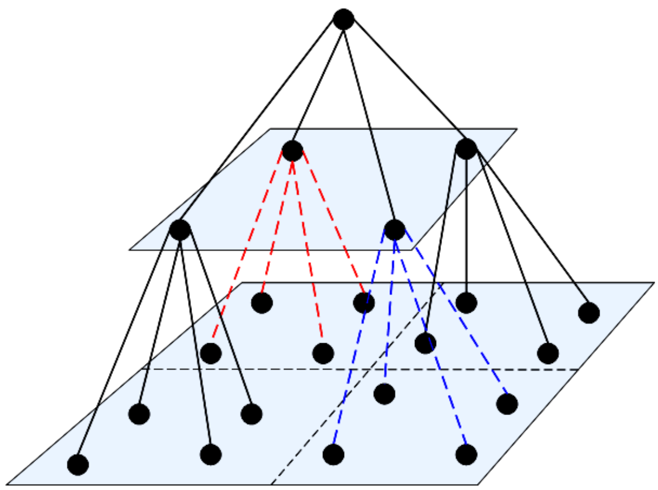

Fig. 3 Block Diagram of Quad Tree Decomposition Structure

IV. SIMULATIONS

Daily sunspot images[2] of each month is fused based on equation (1) and the result of image fusion is shown in Figs. 4, 5, 6 for June, July and August 2001 respectively. These results indicate the existence of some bands of sunspots on both sides of sun meridional in each month. It is obvious from this figures that sunspots with different degree of intensity are lying with different latitude; also sunspots with higher latitude have less intensity. To obtain quantitative information about these latitudes, we applied quad tree decomposition. The decomposition result of fused image of June, July and August 2001 is shown in Figs. 7, 8 and 9 respectively. Analysis the Fig. 4 gives the qualitative insight about the speed of sunspots nearer to sun meridional that rotate faster around the sun. With analysis of Fig. 7 someone can compute the rotation speed of sunspots with different latitudes and obtain a quantitative insight and curve about sunspot speeds.

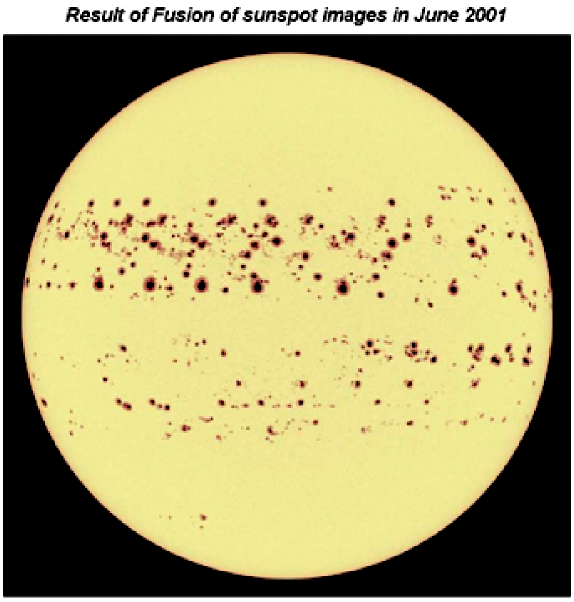

Fig. 4 Sunspot image fusion in June 2001

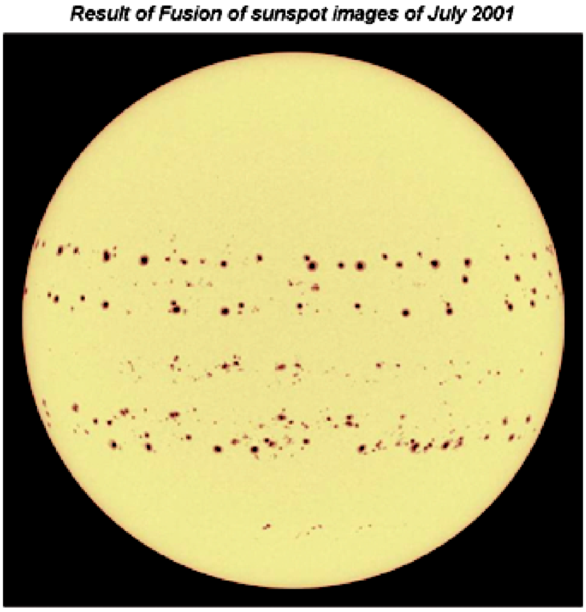

Fig. 5 Sunspot image fusion in July 2001

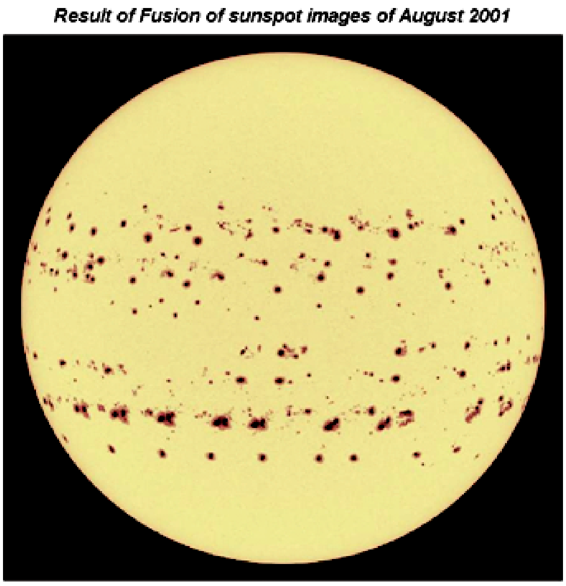

Fig. 6 Sunspot image fusion in August 2001

[2] Sunspot images is taken with SOHO satellite and is downloaded from address: www.spaceweather.com.

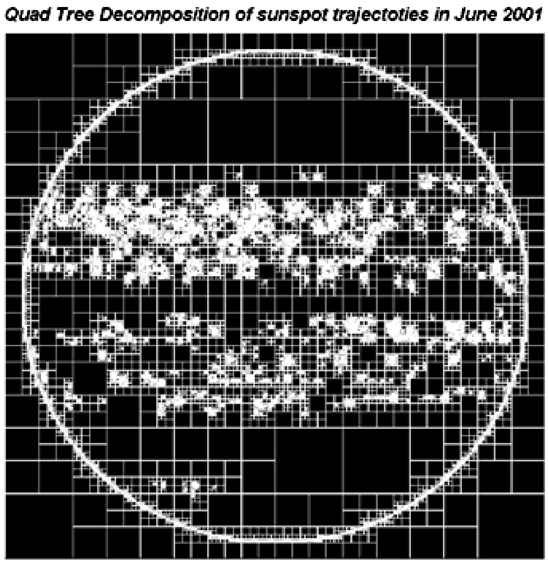

Fig. 7 Classification of sunspot trajectories of June 2001 by Quad Tree decomposition

Based on Fig. 7; two trajectories in July 2001 are classified into latitudes:

(A) One trajectory on top of meridional:
$(11^0) \rightarrow (22.5^0)$

(B) One trajectory on bellow of meridional: $(0^0) \rightarrow (-28^0)$

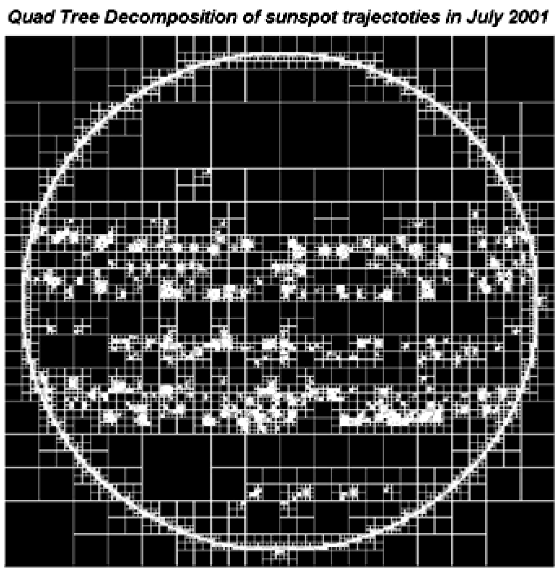

Fig. 8 Classification of sunspot trajectories of July 2001 by Quad Tree decomposition

Based on Fig. 8; four trajectories in July 2001 are classified into latitudes:

(A) Two trajectories on top of meridional $(11^0) \rightarrow (22.5^0)$ and $(23^0) \rightarrow (28.1^0)$

(B) Two trajectories on bellow of meridional: $(-5.6^0) \rightarrow (-22.5^0)$ and $(-28^0) \rightarrow (-45^0)$

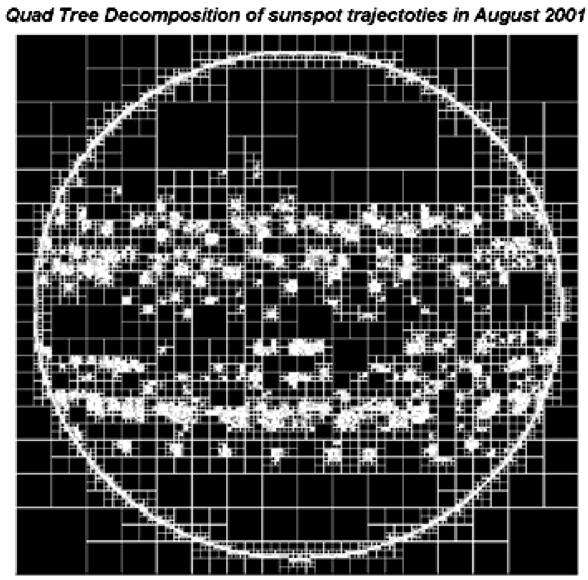

Fig. 9 Classification of sunspot trajectories of August 2001 by Quad Tree decomposition

Based on Fig. 9; two trajectories in August 2001 are classified into latitudes:

(A) One trajectory on top of meridional:
$(0^0) \rightarrow (34^0)$

(B)Two trajectories on bellow of meridional:
$(-11.25^0) \rightarrow (-56^0)$

V. Conclusion

Trajectories latitudes of sunspots was computed by using a combination of image fusion and quad tree decomposition as powerful intelligent tools, and we found that sunspots are rotating along this trajectories in an irregular manner that indicate on chaotic behavior of solar magnetic fields of sun. In consequence, it is worth full to using the method for several months and by computing the latitude band of sunspot belts on sun photosphere and gathering this information and use this information for black-box modeling of variation of this trajectories and finally the prediction of next month trajectories latitude for alert the technical systems. Also it is useful to using this combined method for every two day sunspot images for computation of variation of sunspots in direction of latitude and longitude of sun sphere and using this information for modeling and prediction of co-ordinates of sunspots for next day in order to alert satellites from plasma attack in regions that predicted by this black-box model.

REFERENCES

[1] Lee, S.-S., Horng, S.-J., Tsai, H.-R., Tsai, S.-S.: Building a Quadtree and Its Applications on a Recon_gurable Mesh. Pattern Recognition 29 (1996) 1571-1579.

[2] Julien Burlet, Olivier Aycard and Thierry Fraichard, "Robust Motion Planning using Markov Decision Processes and Quadtree Decomposition", Proceedings of IEEE International Conference on Robotics & Automation, 2004.

[3] Jean-Marc Laferté, Patrick Pérez, and Fabrice Heitz, "Discrete Markov Image Modeling and Inference on the Quadtree", IEEE Transactions On Image Processing, Vol. 9, No: 3, March 2000.

[4] Schrijver C. J., A.M. Title, K. L. Harvey†, N. R. Sheeley Jr, Y.-M. Wang, G. H. J. van den Oord, R. A. Shine, T. D. Tarbell & N. E. Hurlburt, "Large-scale coronal heating by the small-scale magnetic field of the Sun", Nature, Vol. 394 , 9 July 1998.

[5] Wang Y.M, Sheeley Jr N.R, Nash A.G, "Latitudinal distribution of solar wind speed from magnetic observational of the sun ", Nature, VOL 347, 4 October 1990.

[6] Schrijver H. Hasegawa1, M. Fujimoto, T.-D. Phan, H. Re`me, A. Balogh, M. W. Dunlop, C. Hashimoto & R. TanDokoro, "Transport of solar wind into Earth's magnetosphere through rolled-up Kelvin–Helmholtz vortices", Nature, Vol. 430, 12 August 2004.