



US008605979B2

(12) **United States Patent**
Arnold et al.

(10) **Patent No.:** **US 8,605,979 B2**
(45) **Date of Patent:** ***Dec. 10, 2013**

(54) **AUTOMATIC DETECTION AND QUANTIFICATION OF PLAQUE IN THE CORONARY ARTERIES OF SUBJECTS FROM CT SCANS**

(75) Inventors: **Ben A. Arnold**, Columbia, KY (US);
Judd E. Reed, Santa Rosa, CA (US)

(73) Assignee: **Ben A. Arnold**, Columbia, KY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 142 days.
This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/118,256**

(22) Filed: **May 27, 2011**

(65) **Prior Publication Data**

US 2011/0229002 A1 Sep. 22, 2011

Related U.S. Application Data

(63) Continuation of application No. 12/098,425, filed on Apr. 5, 2008, now Pat. No. 7,970,196, which is a continuation of application No. 10/303,663, filed on Nov. 23, 2002, now Pat. No. 7,558,611.

(60) Provisional application No. 60/333,223, filed on Nov. 24, 2001.

(51) **Int. Cl.**
G06K 9/00 (2006.01)

(52) **U.S. Cl.**
USPC **382/131**

(58) **Field of Classification Search**
USPC 382/128, 130, 131; 378/4, 8; 600/426, 600/428

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,233,507 A	11/1980	Volz	250/252
4,649,561 A	3/1987	Arnold	378/207
4,663,772 A	5/1987	Mattson et al.	378/18
4,724,110 A	2/1988	Arnold	264/102
4,782,502 A	11/1988	Schulz	378/18
4,870,666 A	9/1989	Lonn et al.	378/18
4,922,915 A	5/1990	Arnold et al.	128/653 R
4,985,906 A	1/1991	Arnold	378/18
5,034,969 A	7/1991	Ozaki	378/18
5,068,788 A	11/1991	Goodenough et al. ...	364/413.14
5,222,021 A	6/1993	Feldman et al.	364/413.14
5,235,628 A	8/1993	Kalender	378/207
5,335,260 A	8/1994	Arnold	378/207

(Continued)

OTHER PUBLICATIONS

Agatston, Arthur S. et al. Quantification of coronary artery calcium using ultrafast computed tomography, American College of Cardiology, 1990; 15: pp. 827-832.

(Continued)

Primary Examiner — Andrew W Johns

(74) Attorney, Agent, or Firm — Jerry Turner Sewell

(57) **ABSTRACT**

A method automatically detects and quantifies arterial plaque (hard plaque, soft plaque or both) in the coronary arteries of the heart from CT images. The method uses plaque definitions based on subject specific in vivo blood/muscle and fat density measurements, subject specific voxel statistical parameters and 2-D and 3-D voxel connectivity criteria to automatically identify the plaques. The locations of the major arteries are determined in a 3-D coordinate system; and the specific coordinates of the detected plaques are displayed in a plaque map for follow-up exams or ease in plaque review, editing and reporting the results.

22 Claims, 18 Drawing Sheets

