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(54) **DETECTION AND MONITORING OF ATRIAL FIBRILLATION**

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This patent is subject to a terminal disclaimer.

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A61B 5/024	(2006.01)
A61B 5/046	(2006.01)

(52) **U.S. Cl.**

CPC ***A61B 5/7282*** (2013.01); ***A61B 5/02416*** (2013.01); ***A61B 5/046*** (2013.01); ***A61B 5/6898*** (2013.01); *A61B 5/02438* (2013.01); *A61B 5/7264* (2013.01)

(58) **Field of Classification Search**

CPC A61B 5/02416; A61B 5/02438; A61B 5/046; A61B 5/6898; A61B 5/7264

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,682,901	A	11/1997	Kamen	
6,392,584	B1 *	5/2002	Eklund	G01H 1/003 341/183
7,623,911	B2 *	11/2009	Sarkar	A61B 5/0464 600/510
2004/0230105	A1 *	11/2004	Geva	A61B 5/04012 600/301
2007/0032733	A1 *	2/2007	Burton	A61B 5/02405 600/509
2010/0191130	A1 *	7/2010	Glass	A61B 5/0456 600/509
2011/0152957	A1 *	6/2011	Shaquer	A61B 5/046 607/5
2011/0166466	A1 *	7/2011	Chon	A61B 5/046 600/513
2011/0208079	A1	8/2011	Babaeizadeh et al.	

(Continued)

OTHER PUBLICATIONS

Selvaraj, N. et al. "Statistical Approach for the Detection of Motion/Noise Artifacts in Photoplethysmogram." Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Aug. 30-Sep. 3, 2011:4972-4975.

(Continued)

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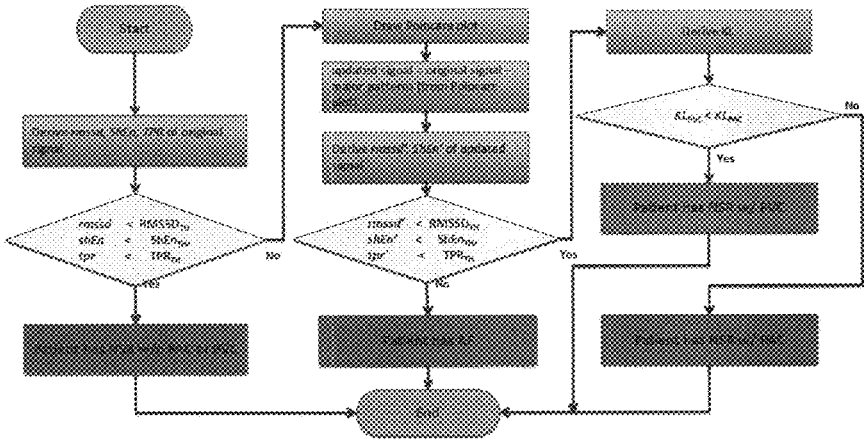
(57) **ABSTRACT**

Enhanced real-time realizable AF algorithm for accurate detection of, and discrimination between, NSR, AF, PVC, and PAC. The method of these teachings includes an AF detection method having a modified Poincare approach in order to differentiate various patterns of PAC and PVC from NSR and AF. The method of these teachings can also apply to the Kullback-Leibler divergence or the Turning Point Ratio (TPR) to differentiate between various patterns of PAC and PVC from NSR and AF.

20 Claims, 16 Drawing Sheets