



US008712723B1

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

(10) **Patent No.:** **US 8,712,723 B1**  
(45) **Date of Patent:** **\*Apr. 29, 2014**

(54) **HUMAN ACTIVITY MONITORING DEVICE**

377/24, 24.1, 24.2; 702/1, 85, 97, 104, 127,  
702/141, 150, 155, 158, 160, 187, 189;  
708/100, 101, 105, 131, 160, 200, 212  
IPC ..... G01B 5/00,5/02; G01C 22/00, 25/00; G01D  
7/00; G01P 13/00; G06F 11/00, 11/30, 11/32,  
G06F 17/00, 17/40, 19/00

(75) Inventors: **Philippe Kahn**, Aptos, CA (US);  
**Arthur Kinsolving**, Santa Cruz, CA  
(US); **Mark Andrew Christensen**, Santa  
Cruz, CA (US); **Brian Y. Lee**, Aptos, CA  
(US); **David Vogel**, Santa Cruz, CA (US)

See application file for complete search history.

(73) Assignee: **DP Technologies, Inc.**, Scotts Valley, CA  
(US)

(56) **References Cited**

(\* ) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 115 days.  
  
This patent is subject to a terminal dis-  
claimer.

U.S. PATENT DOCUMENTS

4,285,041 A 8/1981 Smith  
4,578,769 A 3/1986 Frederick  
5,446,725 A 8/1995 Ishiwatari  
5,446,775 A 8/1995 Wright et al.

(Continued)

(21) Appl. No.: **13/018,321**

FOREIGN PATENT DOCUMENTS

(22) Filed: **Jan. 31, 2011**

JP 2005-309691 A \* 11/2005

**Related U.S. Application Data**

(63) Continuation of application No. 12/694,135, filed on  
Jan. 26, 2010, now Pat. No. 7,881,902, which is a  
continuation of application No. 11/644,455, filed on  
Dec. 22, 2006, now Pat. No. 7,653,508.

OTHER PUBLICATIONS

Cheng, et al, "Periodic Human Motion Description for Sports Video  
Databases," Proceedings of the Pattern Recognition, 2004, 5 pages.

(Continued)

(51) **Int. Cl.**  
**G01C 22/00** (2006.01)  
**G01P 13/00** (2006.01)  
**G06F 19/00** (2006.01)  
**G06F 17/40** (2006.01)

*Primary Examiner* — Edward Cosimano

(74) *Attorney, Agent, or Firm* — Blakely, Sokoloff, Taylor &  
Zafman LLP; Judith A. Szepesi

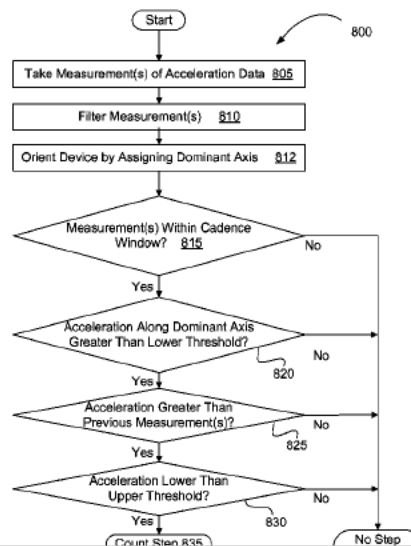
(52) **U.S. Cl.**  
USPC ..... **702/160**; 73/1.79; 377/24.2; 702/97;  
702/187; 702/189; 708/105; 708/200

(57) **ABSTRACT**

A method for monitoring human activity using an inertial  
sensor includes continuously determining an orientation of  
the inertial sensor, assigning a dominant axis, updating the  
dominant axis as the orientation of the inertial sensor  
changes, and counting periodic human motions by monitor-  
ing accelerations relative to the dominant axis.

(58) **Field of Classification Search**  
USPC ..... 33/700, 701; 73/1.01, 1.37, 1.38, 1.75,  
73/1.76, 1.77, 1.78, 1.79, 1.81, 432.1,  
73/865.4, 865.8; 377/1, 13, 15, 17, 19, 20,

**19 Claims, 9 Drawing Sheets**



(56)

References Cited

U.S. PATENT DOCUMENTS

5,485,402	A *	1/1996	Smith et al. ....	702/160	2002/0023654	A1	2/2002	Webb	
5,583,776	A	12/1996	Levi et al.		2002/0089425	A1	7/2002	Kubo et al.	702/165
5,593,431	A	1/1997	Sheldon		2002/0109600	A1	8/2002	Mault et al.	
5,654,619	A	8/1997	Iwashita		2002/0118121	A1	8/2002	Lehrman et al.	
5,778,882	A	7/1998	Raymond et al.		2002/0151810	A1	10/2002	Wong et al.	
5,955,667	A	9/1999	Fyfe		2003/0018430	A1	1/2003	Ladetto et al.	
5,976,083	A	11/1999	Richardson et al.		2003/0048218	A1	3/2003	Milnes et al.	
6,013,007	A	1/2000	Root et al.		2003/0083596	A1	5/2003	Kramer et al.	
6,122,595	A	9/2000	Varley et al.		2003/0109258	A1	6/2003	Mantjarvi et al.	
6,135,951	A	10/2000	Richardson et al.		2003/0139692	A1	7/2003	Barrey et al.	
6,145,389	A	11/2000	Ebeling et al.		2004/0225467	A1	11/2004	Vock et al.	
6,282,496	B1	8/2001	Chowdhary		2004/0236500	A1	11/2004	Choi et al.	
6,353,449	B1	3/2002	Gregg et al.		2005/0033200	A1	2/2005	Soehren et al.	
6,369,794	B1	4/2002	Sakurai et al.		2005/0202934	A1	9/2005	Olrik et al.	
6,428,490	B1	8/2002	Kramer et al.		2005/0210300	A1	9/2005	Song et al.	
6,493,652	B1	12/2002	Ohlenbusch et al.		2005/0222801	A1	10/2005	Wulff et al.	
6,496,695	B1	12/2002	Kouji et al.		2005/0232388	A1	10/2005	Tsuji	
6,513,381	B2	2/2003	Fyfe et al.		2005/0232404	A1	10/2005	Gaskill	
6,522,266	B1	2/2003	Soehren et al.		2005/0238132	A1	10/2005	Tsuji	
6,532,419	B1	3/2003	Begin et al.		2005/0240375	A1	10/2005	Sugai	
6,539,336	B1	3/2003	Vock et al.		2005/0245988	A1	11/2005	Miesel	
6,611,789	B1	8/2003	Darley		2005/0248718	A1	11/2005	Howell et al.	
6,700,499	B2	3/2004	Kubo et al.		2006/0020177	A1	1/2006	Seo et al.	
6,771,250	B1	8/2004	Oh		2006/0063980	A1	3/2006	Hwang et al.	
6,786,877	B2	9/2004	Foxlin		2006/0064276	A1	3/2006	Ren et al.	
6,790,178	B1	9/2004	Mault et al.		2006/0100546	A1	5/2006	Silk	
6,813,582	B2	11/2004	Levi et al.		2006/0136173	A1	6/2006	Case, Jr. et al.	
6,823,036	B1	11/2004	Chen		2006/0149516	A1	7/2006	Bond et al.	
6,826,477	B2	11/2004	Ladetto et al.		2006/0161377	A1	7/2006	Rakkola et al.	
6,836,744	B1	12/2004	Asphahani et al.		2006/0167387	A1	7/2006	Buchholz et al.	
6,881,191	B2	4/2005	Oakley et al.		2006/0174685	A1*	8/2006	Skvortsov et al. ....	73/1.37
6,885,971	B2	4/2005	Vock et al.		2006/0206258	A1	9/2006	Brooks	
6,898,550	B1	5/2005	Blackadar et al.		2006/0223547	A1	10/2006	Chin et al.	
6,928,382	B2	8/2005	Hong et al.		2006/0259268	A1	11/2006	Vock et al.	
6,941,239	B2	9/2005	Unuma et al.		2006/0284979	A1	12/2006	Clarkson	
6,959,259	B2	10/2005	Vock et al.		2006/0288781	A1	12/2006	Daumer et al.	
6,975,959	B2	12/2005	Dietrich et al.		2007/0038364	A1	2/2007	Lee et al.	
7,010,332	B1	3/2006	Irvin et al.		2007/0061105	A1	3/2007	Darley et al.	
7,054,784	B2	5/2006	Flentov et al.		2007/0063850	A1	3/2007	Devaul et al.	
7,057,551	B1	6/2006	Vogt		2007/0067094	A1	3/2007	Park et al.	
7,072,789	B2	7/2006	Vock et al.		2007/0073482	A1	3/2007	Churchill et al.	
7,092,846	B2	8/2006	Vock et al.		2007/0082789	A1	4/2007	Nissila et al.	
7,148,797	B2	12/2006	Albert		2007/0125852	A1	6/2007	Rosenberg	
7,158,912	B2	1/2007	Vock et al.		2007/0130582	A1	6/2007	Chang et al.	
7,169,084	B2	1/2007	Tsuji		2007/0142715	A1	6/2007	Banet et al.	
7,171,331	B2	1/2007	Vock et al.		2007/0143068	A1*	6/2007	Pasolini et al. ....	702/160
7,177,684	B1	2/2007	Kroll et al.		2007/0145680	A1	6/2007	Rosenberg	
7,200,517	B2	4/2007	Darley et al.		2007/0150136	A1	6/2007	Doll et al.	
7,212,943	B2	5/2007	Aoshima et al.		2007/0208531	A1	9/2007	Darley et al.	
7,220,220	B2	5/2007	Stubbs et al.		2007/0213126	A1	9/2007	Deutsch et al.	
7,297,088	B2	11/2007	Tsuji		2007/0250261	A1	10/2007	Soehren	
7,305,323	B2*	12/2007	Skvortsov et al. ....	702/160	2007/0259716	A1	11/2007	Mattice et al.	
7,328,611	B2	2/2008	Klees et al.		2007/0259717	A1	11/2007	Mattice et al.	
7,334,472	B2	2/2008	Seo et al.		2007/0260418	A1	11/2007	Ladetto et al.	
7,353,112	B2	4/2008	Choi et al.		2007/0260482	A1	11/2007	Nurmela et al.	
7,387,611	B2	6/2008	Inoue et al.		2008/0171918	A1	7/2008	Teller et al.	
7,428,471	B2*	9/2008	Darley et al. ....	702/182	2008/0243432	A1*	10/2008	Kato et al. ....	702/160
7,451,056	B2	11/2008	Flentov et al.		2009/0043531	A1	2/2009	Kahn et al.	
7,457,719	B1	11/2008	Kahn et al.		2009/0047645	A1	2/2009	Dibenedetto et al.	
7,463,997	B2*	12/2008	Pasolini et al. ....	702/160	2009/0124348	A1	5/2009	Yoseloff et al.	
7,467,060	B2	12/2008	Kulach et al.		2009/0213002	A1	8/2009	Rani et al.	
7,512,515	B2	3/2009	Vock et al.		2009/0234614	A1	9/2009	Kahn et al.	
7,526,402	B2	4/2009	Tananhaus et al.		2009/0319221	A1	12/2009	Kahn et al.	
7,608,050	B2	10/2009	Shugg		2010/0056872	A1	3/2010	Kahn et al.	
7,617,071	B2*	11/2009	Darley et al. ....	702/165	2010/0057398	A1	3/2010	Darley et al.	
7,640,134	B2*	12/2009	Park et al. ....	702/141					
7,640,804	B2	1/2010	Daumer et al.						
7,647,196	B2	1/2010	Kahn et al.						
7,653,508	B1	1/2010	Kahn et al.						
7,752,011	B2	7/2010	Niva et al.						
7,753,861	B1	7/2010	Kahn et al.						
7,774,156	B2	8/2010	Niva et al.						
7,788,059	B1*	8/2010	Kahn et al. ....	702/141					

OTHER PUBLICATIONS

Heart Rate Monitors, [suunto.com/suunto/Worlds/main/world\\_article\\_product\\_no\\_ATL.jsp?CONTENT%3C%3Ecnt\\_id=10134198676968765&FOLDER%3C%3Efolder\\_id=9852723697225397&ASSORTMENT%3C%3East\\_](http://suunto.com/suunto/Worlds/main/world_article_product_no_ATL.jsp?CONTENT%3C%3Ecnt_id=10134198676968765&FOLDER%3C%3Efolder_id=9852723697225397&ASSORTMENT%3C%3East_)

(56)

**References Cited**

## OTHER PUBLICATIONS

- Jones, L, et al, "Wireless Physiological Sensor System for Ambulatory Use," [ieeexplore.ieee.org/xpl/freeabs\\_all.jsp?tp=&arnumber=1612917&isnumber=33861](http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?tp=&arnumber=1612917&isnumber=33861), Apr. 3-5, 2006.
- "Sensor Fusion," [u-dynamics.com](http://u-dynamics.com), accessed Aug. 29, 2008, 2 pages.
- Sinha, Alex, "Heart Monitoring Training," [marathonguide.com/training/articles/HeartMonitorTraining.cfm](http://marathonguide.com/training/articles/HeartMonitorTraining.cfm), Apr. 4, 2007, 5 pages.
- Wang, Shu, et al, "Location Based Services for Mobiles: Technologies and Standards, LG Electronics MobileComm," IEEE ICC 2008, Beijing, pp. 1-66 (part 1 of 3).
- Wang, Shu, et al, "Location Based Services for Mobiles: Technologies and Standards, LG Electronics MobileComm," IEEE ICC 2008, Beijing, pp. 67-92 (part 2 of 3).
- Wang, Shu, et al, "Location Based Services for Mobiles: Technologies and Standards, LG Electronics MobileComm," IEEE ICC 2008, Beijing, pp. 93-123 (part 3 of 3).
- Weckesser, P, et al, "Multiple Sensorprocessing for High-Precision Navigation and Environmental Modeling with a Mobile Robot," IEEE, 1995, pp. 453-458.
- Yoo, Chang-Sun, et al, "Low Cost GPS/INS Sensor Fusion System for UAV Navigation," IEEE, 2003, 9 pages.
- Anderson, Ian, et al, "Shakra: Tracking and Sharing Daily Activity Levels with Unaugmented Mobile Phones," *Mobile Netw Appl*, Aug. 3, 2007, pp. 185-199.
- Aylward, Ryan, et al, "Senseable: A Wireless, Compact, Multi-User Sensor System for Interactive Dance," *International Conference on New Interfaces for Musical Expression (NIME06)*, Jun. 4-8, 2006, pp. 134-139.
- Baca, Arnold, et al, "Rapid Feedback Systems for Elite Sports Training," *IEEE Pervasive Computing*, Oct.-Dec. 2006, pp. 70-76.
- Bakhr, Kesh, "A Seamless Tracking Solution for Indoor and Outdoor Position Location," *IEEE 16th International Symposium on Personal, Indoor, and Mobile Radio Communications*, 2005, pp. 2029-2033.
- Bliley, Kara E, et al, "A Miniaturized Low Power Personal Motion Analysis Logger Utilizing MEMS Accelerometers and Low Power Microcontroller," *IEEE EMBS Special Topic Conference on Microtechnologies in Medicine and Biology*, May 12-15, 2005, pp. 92-93.
- Fang, Lei, et al, "Design of a Wireless Assisted Pedestrian Dead Reckoning System—The NavMote Experience," *IEEE Transactions on Instrumentation and Measurement*, vol. 54, No. 6, Dec. 2005, pp. 2342-2358.
- Healey, Jennifer, et al, "Wearable Wellness Monitoring Using ECG and Accelerometer Data," *IEEE Int. Symposium on Wearable Computers (ISWC'05)*, 2005, 2 pages.
- Hemmes, Jeffrey, et al, "Lessons Learned Building TeamTrak: An Urban/Outdoor Mobile Testbed," *2007 IEEE Int. Conf. on Wireless Algorithms*, Aug. 1-3, 2007, pp. 219-224.
- Jovanov, Emil, et al, "A Wireless Body Area Network of Intelligent Motion Sensors for Computer Assisted Physical Rehabilitation," *Journal of NeuroEngineering and Rehabilitation*, Mar. 2005, 10 pages.
- Kalpaxis, Alex, "Wireless Temporal-Spatial Human Mobility Analysis Using Real-Time Three Dimensional Acceleration Data," *IEEE Intl. Multi-Conf. on Computing in Global IT (ICCGI'07)*, 2007, 7 pages.
- Milenkovic, Milena, et al, "An Accelerometer-Based Physical Rehabilitation System," *IEEE SouthEastern Symposium on System Theory*, 2002, pp. 57-60.
- Otto, Chris, et al, "System Architecture of a Wireless Body Area Sensor Network for Ubiquitous Health Monitoring," *Journal of Mobile Multimedia*, vol. 1, No. 4, 2006, pp. 307-326.
- Park, Chulsung, et al, "Eco: An Ultra-Compact Low-Power Wireless Sensor Node for Real-Time Motion Monitoring," *IEEE Int. Symp. on Information Processing in Sensor Networks*, 2005, pp. 398-403.
- Shen, Chien-Lung, et al, "Wearable Band Using a Fabric-Based Sensor for Exercise ECG Monitoring," *IEEE Int. Symp. on Wearable Computers*, 2006, 2 pages.
- Tapia, Emmanuel Munguia, et al, "Real-Time Recognition of Physical Activities and Their Intensities Using Wireless Accelerometers and a Heart Rate Monitor," *IEEE Cont. on Wearable Computers*, Oct. 2007, 4 pages.
- Wixted, Andrew J, et al, "Measurement of Energy Expenditure in Elite Athletes Using MEMS-Based Triaxial Accelerometers," *IEEE Sensors Journal*, vol. 7, No. 4, Apr. 2007, pp. 481-488.
- Wu, Winston H, et al, "Context-Aware Sensing of Physiological Signals," *IEEE Int. Conf. on Engineering for Medicine and Biology*, Aug. 23-26, 2007, pp. 5271-5275.
- Bourzac, Katherine "Wearable Health Reports," *Technology Review*, Feb. 28, 2006, [techreview.com/printer\\_friendly\\_article.aspx?id=16431](http://techreview.com/printer_friendly_article.aspx?id=16431), Mar. 22, 2007, 3 pages.
- Dao, Ricardo, "Inclination Sensing with Thermal Accelerometers", *MEMSIC*, May 2002, 3 pages.
- Lee, Seon-Woo, et al., "Recognition of Walking Behaviors for Pedestrian Navigation," *ATR Media Integration & Communications Research Laboratories*, Kyoto, Japan, 4 pages.
- Margaria, Rodolfo, "Biomechanics and Energetics of Muscular Exercise", Chapter 3, pp. 105-125, Oxford: Clarendon Press 1976.
- Mizell, David, "Using Gravity to Estimate Accelerometer Orientation", *Seventh IEEE International Symposium on Wearable Computers*, 2003, 2 pages.
- Ormonet, D., et al., "Learning and Tracking Cyclic Human Motion," *Encyclopedia of Library and Information Science*, vol. 53, supplement 16, 2001, 7 pages.
- PCT International Search Report and Written Opinion for International Application No. PCT/US2008/072537, mailed Oct. 22, 2008, 10 pages.
- PCT International Search Report and Written Opinion for International Application No. PCT/US2009/48523, mailed Aug. 27, 2009, 8 pages.
- Weinberg, Harvey, "MEMS Motion Sensors Boost Handset Reliability" *Jun. 2006*, [mwr.com/Articles/Print.cfm?ArticleID=12740](http://mwr.com/Articles/Print.cfm?ArticleID=12740), Feb. 21, 2007, 4 pages.

\* cited by examiner

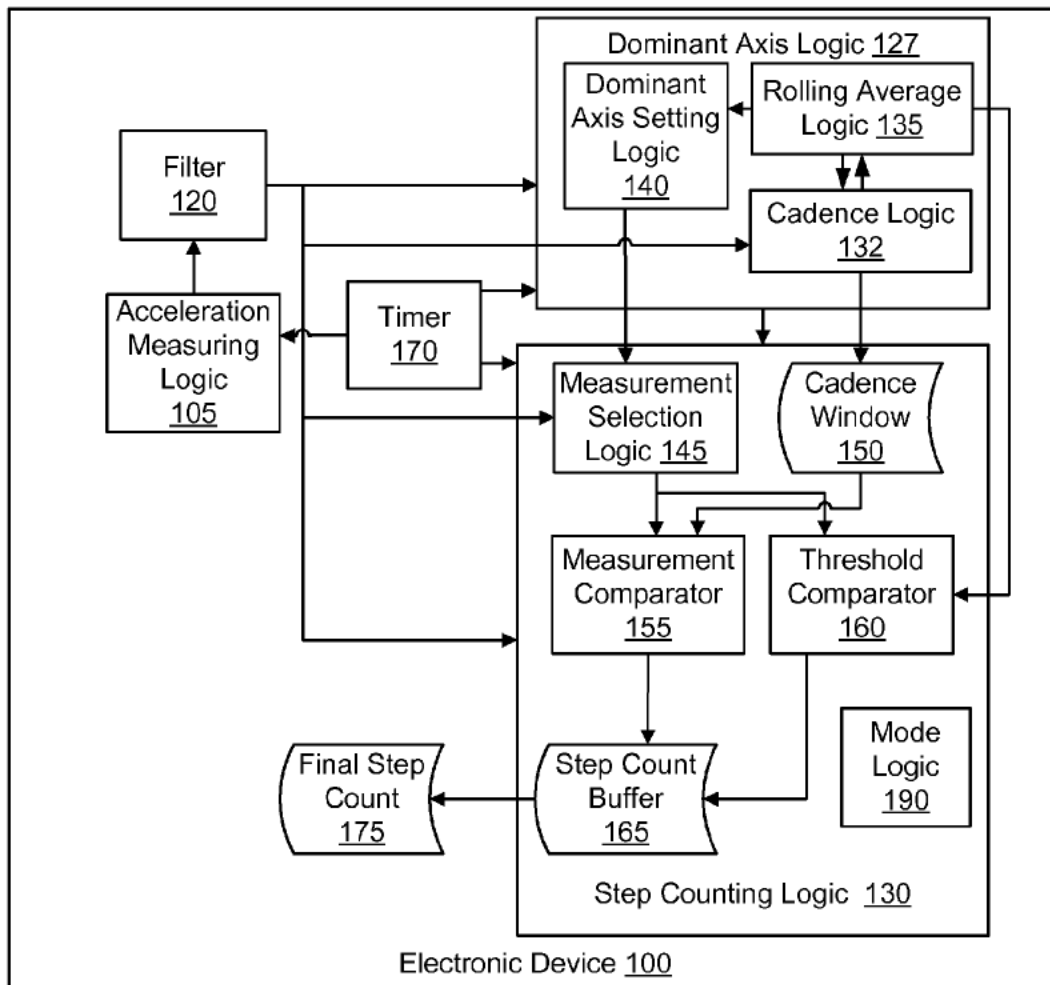


Figure 1

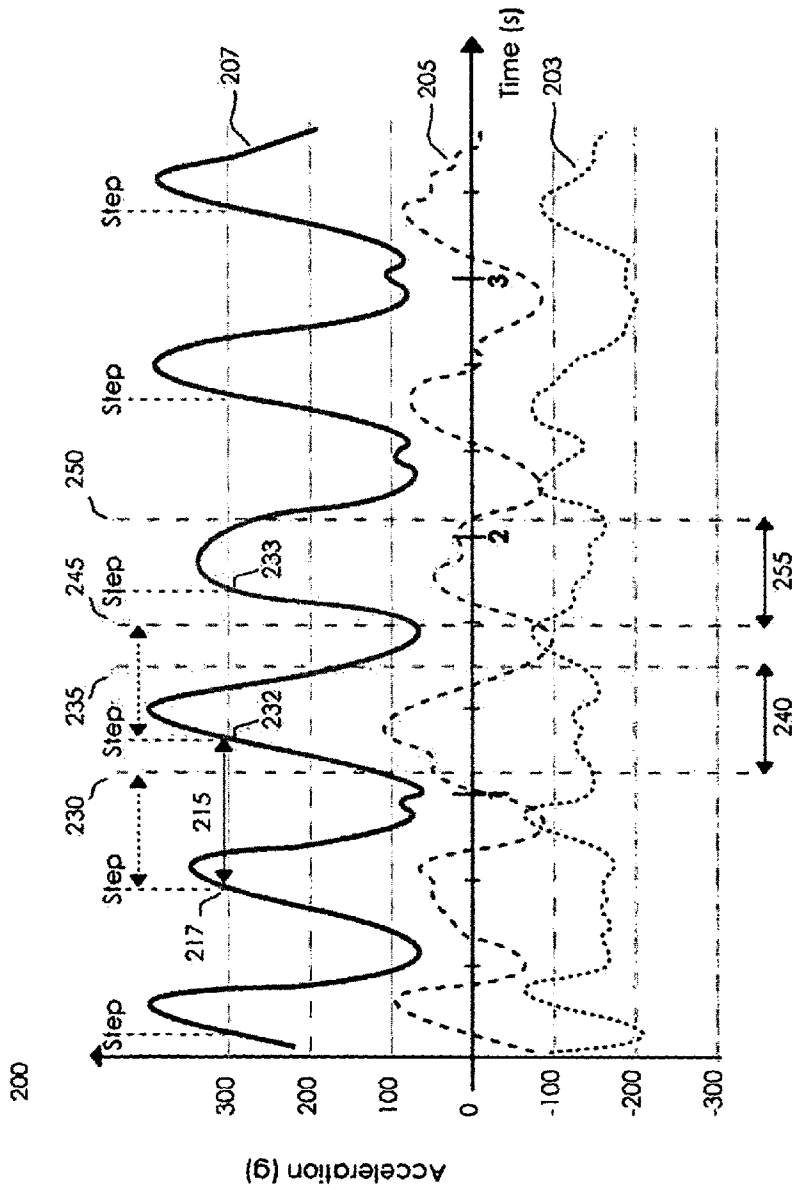


Figure 2

# Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

## Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

## Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

## Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

## API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

## LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

## FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

## E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.