(12) **United States Patent**      (10) **Patent No.:**      **US 8,712,723 B1**

Kahn et al.      (45) **Date of Patent:**      ***Apr. 29, 2014**

(54) **HUMAN ACTIVITY MONITORING DEVICE**

(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)

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

( * ) 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 disclaimer.

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

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

**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.

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

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

(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, 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
See application file for complete search history.

(56) **References Cited**

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)

FOREIGN PATENT DOCUMENTS

JP      2005-309691  A   * 11/2005

OTHER PUBLICATIONS

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

(Continued)

*Primary Examiner* — Edward Cosimano

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

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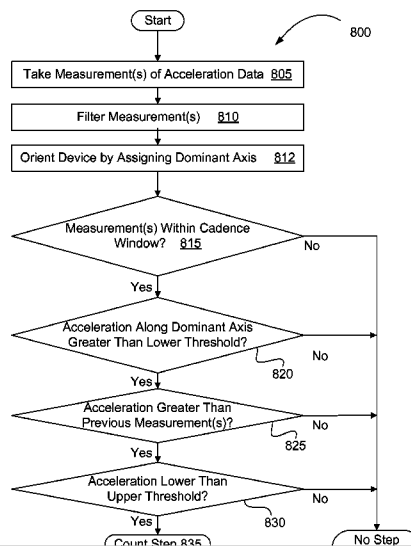
A method for monitoring human activity using an inertial sensor includes continuously determining an orientation of the inertial sensor, assigning a dominant axis, updating the dominant axis as the orientation of the inertial sensor changes, and counting periodic human motions by monitoring accelerations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

**19 Claims, 9 Drawing Sheets**

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | | |
|---|---|---|---|---|---|
| 5,485,402 | A | * | 1/1996 | Smith et al. | 702/160 |
| 5,583,776 | A | | 12/1996 | Levi et al. | |
| 5,593,431 | A | | 1/1997 | Sheldon | |
| 5,654,619 | A | | 8/1997 | Iwashita | |
| 5,778,882 | A | | 7/1998 | Raymond et al. | |
| 5,955,667 | A | | 9/1999 | Fyfe | |
| 5,976,083 | A | | 11/1999 | Richardson et al. | |
| 6,013,007 | A | | 1/2000 | Root et al. | |
| 6,122,595 | A | | 9/2000 | Varley et al. | |
| 6,135,951 | A | | 10/2000 | Richardson et al. | |
| 6,145,389 | A | | 11/2000 | Ebeling et al. | |
| 6,282,496 | B1 | | 8/2001 | Chowdhary | |
| 6,353,449 | B1 | | 3/2002 | Gregg et al. | |
| 6,369,794 | B1 | | 4/2002 | Sakurai et al. | |
| 6,428,490 | B1 | | 8/2002 | Kramer et al. | |
| 6,493,652 | B1 | | 12/2002 | Ohlenbusch et al. | |
| 6,496,695 | B1 | | 12/2002 | Kouji et al. | |
| 6,513,381 | B2 | | 2/2003 | Fyfe et al. | |
| 6,522,266 | B1 | | 2/2003 | Soehren et al. | |
| 6,532,419 | B1 | | 3/2003 | Begin et al. | |
| 6,539,336 | B1 | | 3/2003 | Vock et al. | |
| 6,611,789 | B1 | | 8/2003 | Darley | |
| 6,700,499 | B2 | | 3/2004 | Kubo et al. | |
| 6,771,250 | B1 | | 8/2004 | Oh | |
| 6,786,877 | B2 | | 9/2004 | Foxlin | |
| 6,790,178 | B1 | | 9/2004 | Mault et al. | |
| 6,813,582 | B2 | | 11/2004 | Levi et al. | |
| 6,823,036 | B1 | | 11/2004 | Chen | |
| 6,826,477 | B2 | | 11/2004 | Ladetto et al. | |
| 6,836,744 | B1 | | 12/2004 | Asphahani et al. | |
| 6,881,191 | B2 | | 4/2005 | Oakley et al. | |
| 6,885,971 | B2 | | 4/2005 | Vock et al. | |
| 6,898,550 | B1 | | 5/2005 | Blackadar et al. | |
| 6,928,382 | B2 | | 8/2005 | Hong et al. | |
| 6,941,239 | B2 | | 9/2005 | Unuma et al. | |
| 6,959,259 | B2 | | 10/2005 | Vock et al. | |
| 6,975,959 | B2 | | 12/2005 | Dietrich et al. | |
| 7,010,332 | B1 | | 3/2006 | Irvin et al. | |
| 7,054,784 | B2 | | 5/2006 | Flentov et al. | |
| 7,057,551 | B1 | | 6/2006 | Vogt | |
| 7,072,789 | B2 | | 7/2006 | Vock et al. | |
| 7,092,846 | B2 | | 8/2006 | Vock et al. | |
| 7,148,797 | B2 | | 12/2006 | Albert | |
| 7,158,912 | B2 | | 1/2007 | Vock et al. | |
| 7,169,084 | B2 | | 1/2007 | Tsuji | |
| 7,171,331 | B2 | | 1/2007 | Vock et al. | |
| 7,177,684 | B1 | | 2/2007 | Kroll et al. | |
| 7,200,517 | B2 | | 4/2007 | Darley et al. | |
| 7,212,943 | B2 | | 5/2007 | Aoshima et al. | |
| 7,220,220 | B2 | | 5/2007 | Stubbs et al. | |
| 7,297,088 | B2 | | 11/2007 | Tsuji | |
| 7,305,323 | B2 | * | 12/2007 | Skvortsov et al. | 702/160 |
| 7,328,611 | B2 | | 2/2008 | Klees et al. | |
| 7,334,472 | B2 | | 2/2008 | Seo et al. | |
| 7,353,112 | B2 | | 4/2008 | Choi et al. | |
| 7,387,611 | B2 | | 6/2008 | Inoue et al. | |
| 7,428,471 | B2 | * | 9/2008 | Darley et al. | 702/182 |
| 7,451,056 | B2 | | 11/2008 | Flentov et al. | |
| 7,457,719 | B1 | | 11/2008 | Kahn et al. | |
| 7,463,997 | B2 | * | 12/2008 | Pasolini et al. | 702/160 |
| 7,467,060 | B2 | | 12/2008 | Kulach et al. | |
| 7,512,515 | B2 | | 3/2009 | Vock et al. | |
| 7,526,402 | B2 | | 4/2009 | Tananhaus et al. | |
| 7,608,050 | B2 | | 10/2009 | Shugg | |
| 7,617,071 | B2 | * | 11/2009 | Darley et al. | 702/165 |
| 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 |
| 7,892,080 | B1 | | 2/2011 | Dahl | |
| 7,962,312 | B2 | * | 6/2011 | Darley et al. | 702/165 |
| 7,987,070 | B2 | * | 7/2011 | Kahn et al. | 702/160 |
| 8,187,182 | B2 | * | 5/2012 | Kahn et al. | 600/300 |
| 2002/0023654 | A1 | | 2/2002 | Webb | |
| 2002/0089425 | A1 | | 7/2002 | Kubo et al. | |
| 2002/0109600 | A1 | | 8/2002 | Mault et al. | |
| 2002/0118121 | A1 | | 8/2002 | Lehrman et al. | |
| 2002/0151810 | A1 | | 10/2002 | Wong et al. | |
| 2003/0018430 | A1 | | 1/2003 | Ladetto et al. | |
| 2003/0048218 | A1 | | 3/2003 | Milnes et al. | |
| 2003/0083596 | A1 | | 5/2003 | Kramer et al. | |
| 2003/0109258 | A1 | | 6/2003 | Mantyjarvi et al. | |
| 2003/0139692 | A1 | | 7/2003 | Barrey et al. | |
| 2004/0225467 | A1 | | 11/2004 | Vock et al. | |
| 2004/0236500 | A1 | | 11/2004 | Choi et al. | |
| 2005/0033200 | A1 | | 2/2005 | Soehren et al. | |
| 2005/0202934 | A1 | | 9/2005 | Olrik et al. | |
| 2005/0210300 | A1 | | 9/2005 | Song et al. | |
| 2005/0222801 | A1 | | 10/2005 | Wulff et al. | |
| 2005/0232388 | A1 | | 10/2005 | Tsuji | |
| 2005/0232404 | A1 | | 10/2005 | Gaskill | |
| 2005/0238132 | A1 | | 10/2005 | Tsuji | |
| 2005/0240375 | A1 | | 10/2005 | Sugai | |
| 2005/0245988 | A1 | | 11/2005 | Miesel | |
| 2005/0248718 | A1 | | 11/2005 | Howell et al. | |
| 2006/0020177 | A1 | | 1/2006 | Seo et al. | |
| 2006/0063980 | A1 | | 3/2006 | Hwang et al. | |
| 2006/0064276 | A1 | | 3/2006 | Ren et al. | |
| 2006/0100546 | A1 | | 5/2006 | Silk | |
| 2006/0136173 | A1 | | 6/2006 | Case, Jr. et al. | |
| 2006/0149516 | A1 | | 7/2006 | Bond et al. | |
| 2006/0161377 | A1 | | 7/2006 | Rakkola et al. | |
| 2006/0167387 | A1 | | 7/2006 | Buchholz et al. | |
| 2006/0174685 | A1 | * | 8/2006 | Skvortsov et al. | 73/1.37 |
| 2006/0206258 | A1 | | 9/2006 | Brooks | |
| 2006/0223547 | A1 | | 10/2006 | Chin et al. | |
| 2006/0259268 | A1 | | 11/2006 | Vock et al. | |
| 2006/0284979 | A1 | | 12/2006 | Clarkson | |
| 2006/0288781 | A1 | | 12/2006 | Daumer et al. | |
| 2007/0038364 | A1 | | 2/2007 | Lee et al. | |
| 2007/0061105 | A1 | | 3/2007 | Darley et al. | |
| 2007/0063850 | A1 | | 3/2007 | Devaul et al. | |
| 2007/0067094 | A1 | | 3/2007 | Park et al. | |
| 2007/0073482 | A1 | | 3/2007 | Churchill et al. | |
| 2007/0082789 | A1 | | 4/2007 | Nissila et al. | |
| 2007/0125852 | A1 | | 6/2007 | Rosenberg | |
| 2007/0130582 | A1 | | 6/2007 | Chang et al. | |
| 2007/0142715 | A1 | | 6/2007 | Banet et al. | |
| 2007/0143068 | A1 | * | 6/2007 | Pasolini et al. | 702/160 |
| 2007/0145680 | A1 | | 6/2007 | Rosenberg | |
| 2007/0150136 | A1 | | 6/2007 | Doll et al. | |
| 2007/0208531 | A1 | | 9/2007 | Darley et al. | |
| 2007/0213126 | A1 | | 9/2007 | Deutsch et al. | |
| 2007/0250261 | A1 | | 10/2007 | Soehren | |
| 2007/0259716 | A1 | | 11/2007 | Mattice et al. | |
| 2007/0259717 | A1 | | 11/2007 | Mattice et al. | |
| 2007/0260418 | A1 | | 11/2007 | Ladetto et al. | |
| 2007/0260482 | A1 | | 11/2007 | Nurmela et al. | |
| 2008/0171918 | A1 | | 7/2008 | Teller et al. | |
| 2008/0243432 | A1 | * | 10/2008 | Kato et al. | 702/160 |
| 2009/0043531 | A1 | | 2/2009 | Kahn et al. | |
| 2009/0047645 | A1 | | 2/2009 | Dibenedetto et al. | |
| 2009/0124348 | A1 | | 5/2009 | Yoseloff et al. | |
| 2009/0213002 | A1 | | 8/2009 | Rani et al. | |
| 2009/0234614 | A1 | | 9/2009 | Kahn et al. | |
| 2009/0319221 | A1 | | 12/2009 | Kahn et al. | |
| 2010/0056872 | A1 | | 3/2010 | Kahn et al. | |
| 2010/0057398 | A1 | | 3/2010 | Darley et al. | |

OTHER PUBLICATIONS

Heart Rate Monitors, .suunto.com/suunto/Worlds/main/world__article__product__no__ATL.jsp?CONTENT%3C%3Ecnt__id=10134198676968765&FOLDER%3C%3Efolder__d=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>, Apr. 3-5, 2006.

"Sensor Fusion," .u-dynamics.com>, accessed Aug. 29, 2008, 2 pages.

Sinha, Alex, "Heart Monitoring Training," .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 Unagmented Mobile Phones," Mobile Netw Appl, Aug. 3, 2007, pp. 185-199.

Aylward, Ryan, et al, "Sensemble: 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.

Bakhru, 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, 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.

Ormoneit, 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, mwrf.com/Articles/Print.cfm?ArticleID=12740, Feb. 21, 2007, 4 pages.
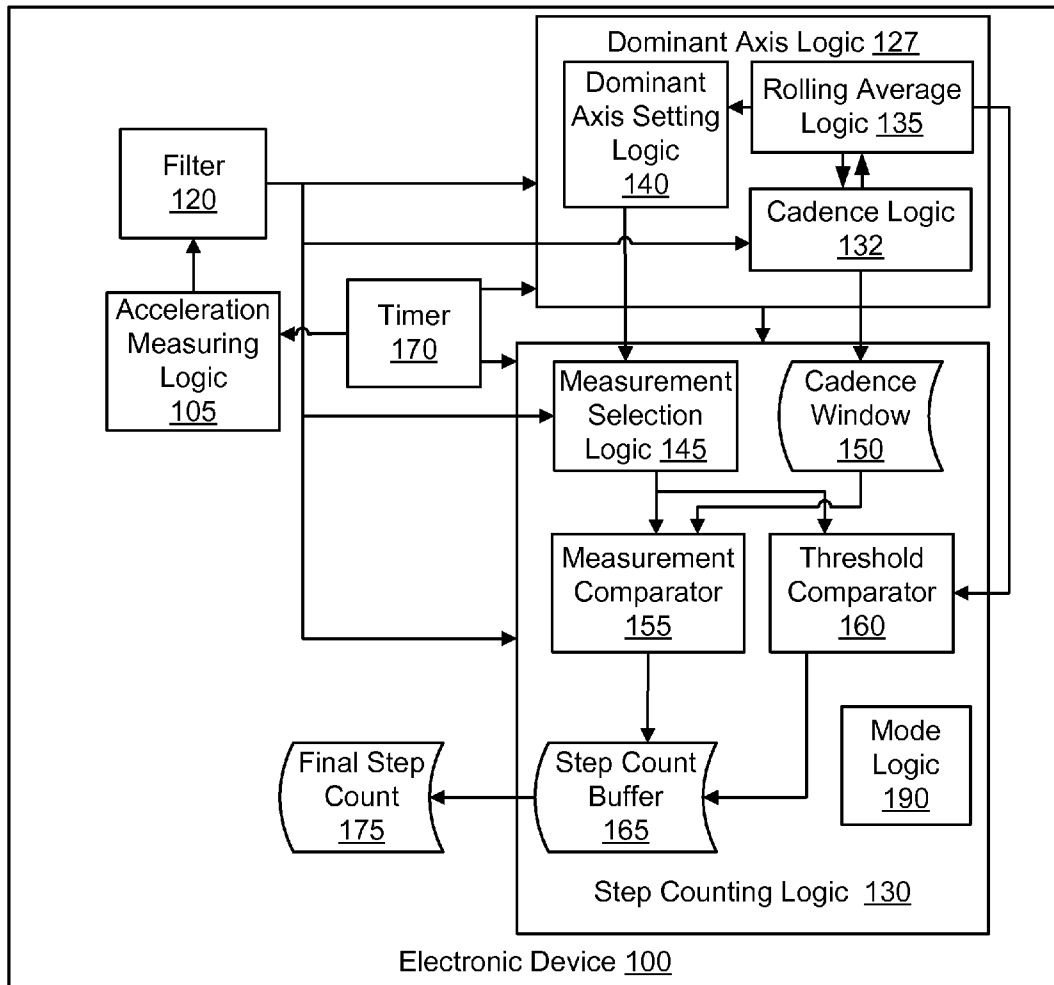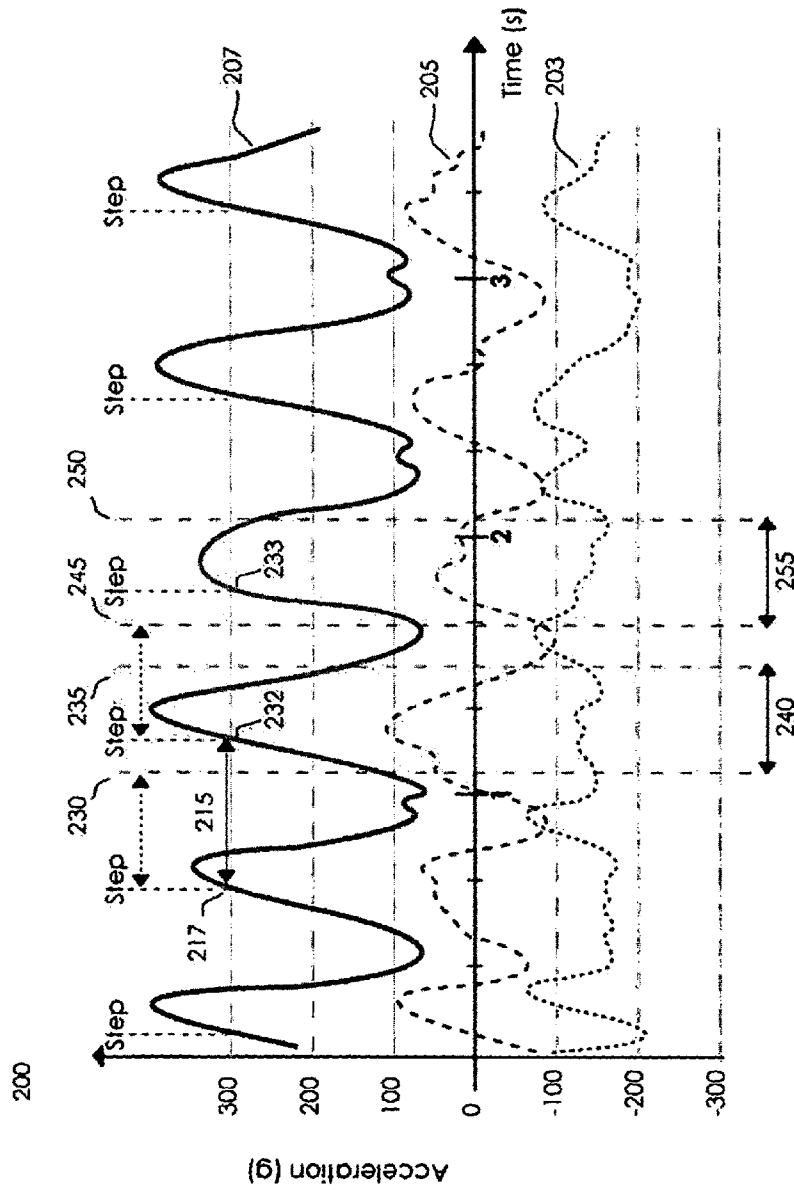
* cited by examiner

Figure 1

Figure 2

# DOCKET ALARM

# 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.

fastcase
Smarter legal research.