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(54) DETECTION METHOD FOR VOLLEYBALL TECHNIQUE

DETEKTIONSVERFAHREN FÜR VOLLEYBALLTECHNIK

PROCÉDÉ DE DÉTECTION DE TECHNIQUE DE VOLLEY-BALL

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Description

[0001] The present invention concerns a method of detection for an electronic apparatus comprising a case containing an electronic module powered with electrical energy by a means of storing electrical energy, said electronic module including a calculation unit connected to an acceleration sensor and to a memory unit, said electronic module also being connected to a display means so as to display information linked to some data of said acceleration sensor

BACKGROUND OF THE ART

[0002] A portable electronic object, such as an electronic device or, for example, a portable timepiece, includes a case generally formed of a middle part closed by a back cover and by a glass. Inside the case is arranged an electronic module so as to provide an information. This information could be an information linked to an activity. These activities are mainly linked to fitness like running or walking.

[0003] To do this, the electronic module includes at least one sensor like an acceleration sensor. This electronic circuit also included a calculation unit so as to use data coming from the acceleration sensor and a memory to save them.

[0004] In the calculation unit, an algorithm is implemented. Said algorithm is programmed to treat said data so as to obtain data representative of an activity.

[0005] However, currently, it is difficult to have an algorithm which is able to precisely determine the activity. For example, for pedometer, it is quite difficult for the calculation unit and the algorithm to determine if the user walks or runs. Yet, the determination of a walking activity or a running activity is important to calculate the crossed distance.

[0006] Consequently, if it is difficult to determine the action for simple activity like running or walking, it is more difficult to provide a portable object for detected complex actions like volleyball.

[0007] Indeed, in volleyball, there are different categories of volleyball techniques that can be differentiated. In addition to that, the force of the impact on the ball is determined, named "smash power" hereinafter.

[0008] US 2014/275854 A1 discloses a method for detecting and analyzing an activity by means of a specific app dedicated to said activity, said app being installed on a watch worn by a user. While performing the activity, the user must press a button on the watch to launch said app. As a consequence, many different apps need to be installed on the watch to cover all the activities that might be performed.

[0009] US 2011/196262 A1 discloses a method for analyzing a muscle effort by means of an acceleration sensor compressed against the muscle body, for instance by means of an adhesive. Not only this method is inconvenient for the sportsperson, but it does not enable determining which kind of activity is performed, given several activities may imply the same reply from the considered muscle.

[0010] US 6522266 B1 discloses a neural network system designed to identify and classify different types of human motion, especially walking, walking sideways, walking up or down a slope or stairs, turning left or right and running. However, this system is not sophisticated enough to differentiate between different categories of volleyball techniques.

SUMMARY OF THE INVENTION

[0011] The object of the present invention is to provide an algorithm, used for example in a volleyball activity, able to detect and characterize ball contacts in a beach volleyball game like serves, passes, digs etc.

[0012] The invention therefore concerns a method of detection for an electronic apparatus comprising a case containing an electronic module powered with electrical energy by a means of storing electrical energy, said electronic module including a calculation unit connected to an acceleration sensor and to a memory unit, said electronic module also being connected to a display means so as to display information linked to some data of said acceleration sensor, the method being implemented by means of an algorithm and including the steps of:

- Acquiring data from the acceleration sensor;
- Detecting potential activities using a high-pass filter for filtering the acquired data so as to detect fast changes of the measured acceleration and using a low pass filter to filter a calculated norm of the high-passed filtered data to only detect significant activities;
- Filtering the maxima of the low-pass filtered high pass norm above a second threshold to reject more of the non-relevant activities and to determine peak/hit of this norm;
- Preparing the data for the classification wherein acceleration data before and after the peak/hit is low-pass filtered from data at the ends of a data interval centered on the peak to data at the peak/hit, and down-sampled, starting with the value closest to the hit;
- Handing over the down-sampled data to the classification step of the algorithm;
- Classifying what activity occurred, by the algorithm;
- Characterizing the activity, based on a 1-Nearest Neighbor algorithm using the L1-norm in the down sampled acceleration space.

[0013] In a first advantageous embodiment, the calculation unit is able to pass from a low power mode wherein said calculation unit sleeps to a normal mode wherein said calculation unit wakes up if the acceleration sensor which constantly acquires data with approximately an appropriate frequency, measures an acceleration data above a determined threshold.

[0014] In a second advantageous embodiment, the low-pass filter and the high-pass filter use an infinite-impulse response filter of second order.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The objects, advantages and features of the portable electronic device or object will appear more clearly in the following detailed description of at least one embodiment of the invention, given solely by way of non-limiting example and illustrated by the annexed drawings, in which:

- Figures 1 and 2 are schematic diagram of the managing method according to the invention.
- Figure 3 is a schematic diagram of a characterizing step according to the invention.

DETAILED DESCRIPTION

[0016] The portable object on which the method of the present invention may be implemented could be a wristwatch comprised in a case. Said case forms a housing wherein an electronic circuit is placed. Said electronic circuit comprises a calculation unit or processing unit for managing the electronic circuit, a sensor for acquiring data and a memory so as to save these data. The portable object also comprises display means like LCD display so as to display the data.

[0017] This portable object could be used during sport activity like volleyball. In volleyball, there are numerous different categories of volleyball techniques that can be differentiated like a dig, a dig with a jump, a lower pass, a high pass, an attack, a jump attack and so on. In addition to that, the force of the impact on the ball is determined, named "smash power" hereinafter. Common to the volleyball techniques is that the ball normally hits the lower arm in close proximity to the wrist. This gives the possibility to acquire acceleration sensor data with a watch on the wrist to determine and characterize the used techniques.

[0018] The sensor is a 3D acceleration sensor with a measurement range between -16g and +16g is attached to the wrist in such a way that the sensor axes are aligned with the lower arm. Pointing along the lower arm bone, perpendicular to the palm of the hand and horizontally when the arm is pointing downwards. For example, this is useful since many of the arm movements during a volleyball game are causing distinct accelerations along these axes. The acceleration sensor is set to acquire data with a frequency comprised between 30Hz and 50Hz, preferably between 35Hz and 45Hz, most preferred about 40 Hz in the low power mode.

[0019] The calculation unit of the portable object further includes an algorithm able to treat said acceleration data so as to obtain data representative of an activity. For the present description, the activity is volleyball. The volleyball action detection algorithm is based on a multi-layer approach as seen in Figures 1 and 2. An activity is defined by a change in acceleration data above a certain threshold. In the watch, it is used an activity interrupt in such a way that only when the acceleration sensor detects an activity, the operating system is notified and the acceleration data is retrieved. If the sensor does not detect an activity and therefore does not send an activity interrupt to the operating system, the operating system would never retrieve the acceleration data and therefore never start the algorithm.

[0020] In the first step of the detection algorithm, the acceleration sensor is set to a threshold-interrupt mode, constantly acquiring data in the low power mode with approximately 40 Hz, storing it in a ring-buffer and checking whether an acceleration above a determined threshold is measured. This threshold should be comprised between 1g and 3g, preferably between 1.5g and 2.5g and most preferred about 2g. In case an acceleration above the threshold is measured, the microcontroller on which the algorithm is running wakes up and the ring-buffered acceleration data is transferred to the microcontroller. To explain more precisely, the acceleration sensor acquires data with a certain rate. In the present case 40 Hz. The acceleration data is then first stored in the acceleration sensor itself until the operating system retrieves the acceleration data in chunks. By setting a watermark interrupt, the operating system tells the acceleration sensor how many datasets the acceleration sensor should store until it notifies the Operating system. In our case, the watermark was set to 20. That means, each time the acceleration sensor stored a number of 20 datasets it notifies the operating system. The operating system then retrieves the acceleration data from the sensor thereby moving the data out of the storage of the sensor into the operating system. The acceleration sensor then fills up its own storage again with new acceleration data and again notifies the operating system once it reaches 20 acceleration datasets in storage. The limit of in our case 20 is called the watermark level. Each time the watermark level is reached the acceleration sensor sends a system interrupt to the operating system. Causing the operating system to retrieve the sensor data.

[0021] The second step of the detection algorithm is to detect potential volleyball activities. To do this, the acceleration data is high-pass filtered with an efficient infinite-impulse response (IIR) filter of second order. The cut-off frequency should be comprised between 5Hz and 15Hz, preferably between 7Hz and 13Hz and most preferred about 9Hz. This is done to detect fast changes of the measured acceleration.

[0022] To only detect significant activities, i.e. ball con-

tact with the arm, the norm (squared sum of the x-y-z axis) of the high-passed filtered data is calculated and low pass filtered (again with an IIR filter of second order). The cut-off frequency should be comprised between 1Hz and 10Hz, preferably between 2Hz and 6Hz and most preferred about 3Hz.

[0023] Likely times for a volleyball technique might be peaks of this norm above a second threshold. This second threshold should be comprised between 0.1 g and 1g, preferably between 0.2g and 0.6g, most preferred about 0.3g. At this stage the detected maxima were approximately 55% to 70% non-relevant activities and 30% to 45% volleyball activities of interest. The response delay of the IIR filters with respect to the raw acceleration data is taken into account for all the following operations.

[0024] In a third step, maxima of the low-pass filtered high pass norm above the second threshold are further analyzed in another filter to reject more of the non-relevant activities.

[0025] Data analysis showed that most of the non-relevant maxima of the filter described in the second step had a relatively low value of the high-passed maxima and a low value for the norm of the raw acceleration data just before the peak (between 5 and 10 raw accelerations values before the peak were averaged), while most of the relevant volleyball activities are characterized either by a high peak in the high-passed data or a high value of the raw acceleration data or both.

[0026] This filter is implemented by separating the 2D space (high-pass norm peak value and raw acceleration norm before the peak) by a line with peaks above the line being further processed and peaks below (relatively low high-pass peak and low raw acceleration norm) the line are sorted out. This reduces the ratio of non-relevant to relevant volleyball activities (ball contact, i.e. hit) to approximately 1:1. There are about 25 to 35 (for each acceleration sensor axis) raw acceleration measurements before and 15 to 25 after the high-pass peak (i.e. likely ball contact) are then transferred to the next function.

[0027] In the fourth step of the algorithm, the data is prepared for the classification. The 3D raw acceleration data before and after the peak/hit (not including the acceleration data at the peak) is low-pass filtered from both ends towards the hit, this means that, in a data interval centered on the peak, the filtering is operated from the data at the ends of the interval to the data towards said peak. The 3D raw acceleration data are also down-sampled by a factor between 2 and 4, starting with the value closest to the hit (from the hit towards the ends). The low-pass filter could be the same IIR filter as the filter disclosed and used in the second step.

[0028] The down-sampled data is then handed over the classification step of an algorithm that tries to determine what kind of activity and preferentially volleyball activity occurred (also sorting out non-relevant activities).

[0029] In a fifth step, volleyball technique characterization is done as seen in Figure 3. Said volleyball technique characterization is based on a 1-Nearest Neighbor algorithm using the L1-norm in the downsampled acceleration data space. The L1-norm is calculated to cluster centers each uniquely related to a volleyball technique (i.e. jump attack, serve low, ...) or several other common activities which occur during a normal volleyball game (i.e. clapping, checks with on another) or fan activities like clapping or la Ola. Each volleyball technique is linked to a memory location. Thus, each time the volleyball technique occurs, the number in the memory location is increased. So, at the end, it is possible to display the number of occurrence for each volleyball technique with a timestamp of when it occurred

[0030] In an alternative example, the method according to the present invention also includes a sixth step. In this sixth step, the smash power, which correlates with the ball speed, is determined. The smash power is determined in the following way: When a volleyball technique was detected the raw acceleration data in a certain window of about 0.6s to 0.8s before and after the hit is band passed with an IIR filter of second order. The sum over the norm of the band-passed filtered data highly correlates with the speed of the ball. Since the watch only reserved 2 digits to display the integrated smash power the sum over the band-pass filtered data is scaled to a range from 0 to 99. Multiplying the smash power with another factor, it is possible to determine a ball speed that highly correlates with the actual ball speed.

[0031] Said power is affiliated to a volleyball technique. Said power is also saved in the memory. The memory could be managed so that for each detected volleyball activity, the power of said detected activity is saved. It must be understood that for each smash or each pass or each serve, the power is saved. The portable object is thus able to display, for each occurrence, the power of the volleyball activity.

[0032] Each time a volleyball activity is detected and saved by the volleyball algorithm the operating system of the watch is notified. In this way the watch can update the display.

[0033] It will be clear that various alterations and/or improvements and/or combinations evident to those skilled in the art may be made to the various embodiments of the invention set out above without departing from the scope of the invention defined by the annexed claims.

[0034] It will be understood that this method could be used for others activities like basketball or baseball or tennis or badminton. Moreover, it will be understood that this method could be used to differentiate a clap of a player from a hit or a serve. Consequently, the efficiency of the portable object including said method is higher. It is also possible to have a specific function in the portable object concerning clapping or la ola.

Claims

1. Method of detection for an electronic apparatus com-

prising a case containing an electronic module powered with electrical energy by a means of storing electrical energy, said electronic module including a calculation unit connected to an acceleration sensor and to a memory unit, said electronic module also being connected to a display means so as to display information linked to some data of said acceleration sensor, the method being implemented by means of an algorithm and including the steps of:

- Acquiring data from the acceleration sensor;
- Detecting potential activities using a high-pass filter for filtering the acquired data so as to detect fast changes of the measured acceleration and using a low pass filter to filter a calculated norm of the high-passed filtered data to only detect significant activities;
- Filtering the maxima of the low-pass filtered high pass norm above a second threshold to reject more of the non-relevant activities and to determine peak/hit of this norm;
- Preparing the data for the classification wherein acceleration data before and after the peak/hit is low-pass filtered from data at the ends of a data interval centered on the peak to data at the hit, and down-sampled, starting with the value closest to the hit;
- Handing over the down-sampled data to the classification step of the algorithm;
- Classifying what activity occurred, by the algorithm;
- Characterizing the activity, based on a 1-Nearest Neighbor algorithm using the L1-norm in the down sampled acceleration space.

2. Method according to claim 1, wherein the calculation unit is able to pass from a low power mode wherein said calculation unit sleeps to a normal mode wherein said calculation unit wakes up if the acceleration sensor which constantly acquires data with a frequency approximately comprised between 30 to 50Hz, measures an acceleration data above a determined threshold.

3. Method according to claim 2, wherein the determined threshold is comprised between 1.5 and 2.5g.

4. Method according to one of the preceding claims, wherein the low-pass filter and the high-pass filter use a filter of second order.

5. Method according to claim 1, wherein the second threshold is comprised between 0.2 and 0.6g.

Patentansprüche

1. Detektionsverfahren für eine elektronische Vorrichtung, die ein Gehäuse umfasst, das ein elektronisches Modul enthält, das durch Mittel zum Speichern von elektrischer Energie mit elektrischer Energie versorgt wird, wobei das elektronische Modul eine Berechnungseinheit aufweist, die mit einem Beschleunigungssensor und mit einer Speichereinheit verbunden ist, wobei das elektronische Modul ferner mit Anzeigemitteln verbunden ist, um Informationen anzuzeigen, die mit einigen Daten des Beschleunigungssensors verknüpft sind, wobei das Verfahren mittels eines Algorithmus durchgeführt wird und die Schritte umfasst:

- Erfassen von Daten von dem Beschleunigungssensor;
- Detektieren möglicher Aktivitäten unter Verwendung eines Hochpassfilters zum Filtern der erfassten Daten, um so schnelle Änderungen der gemessenen Beschleunigung zu detektieren, und unter Verwendung eines Tiefpassfilters, um eine berechnete Norm der mit dem Hochpass gefilterten Daten zu filtern, um nur signifikante Aktivitäten zu detektieren;
- Filtern der Maxima der mit dem Tiefpass gefilterten Hochpassnorm oberhalb eines zweiten Schwellenwerts, um mehrere der nicht relevanten Aktivitäten auszusortieren und um einen Maximalwert/Treffer dieser Norm zu bestimmen;
- Aufbereiten der Daten für die Klassifizierung, wobei Beschleunigungsdaten vor und nach dem Maximalwert/Treffer von Daten an den Enden eines Datenintervalls, das um den Maximalwert zentriert ist, zu Daten bei dem Treffer mit einem Tiefpass gefiltert und abwärts abgetastet werden, wobei mit dem Wert begonnen wird, der dem Treffer am nächsten liegt;
- Übergeben der abwärts abgetasteten Daten an den Klassifizierungsschritt des Algorithmus;
- Klassifizieren durch den Algorithmus, welche Aktivität eintrat;
- Charakterisieren der Aktivität auf der Basis eines 1-Nächste-Nachbarn-Algorithmus unter Verwendung der L1-Norm in dem abwärts abgetasteten Beschleunigungsraum.

2. Verfahren nach Anspruch 1, wobei die Berechnungseinheit von einer Betriebsart mit geringem Energieverbrauch, in der die Berechnungseinheit im Ruhezustand ist, zu einer normalen Betriebsart übergeht, in der die Berechnungseinheit aktiv wird, wenn der Beschleunigungssensor, der gleichmäßig Daten mit einer Frequenz erfasst, die ungefähr im Bereich zwischen 30 und 50 Hz liegt, Beschleunigungsdaten oberhalb eines festgelegten Schwellenwerts misst.

3. Verfahren nach Anspruch 2, wobei der festgelegte Schwellenwert im Bereich von 1,5 bis 2,5 g liegt.

4. Verfahren nach einem der vorhergehenden Ansprüche, wobei das Tiefpassfilter und das Hochpassfilter ein Filter zweiter Ordnung verwenden.

5. Verfahren nach Anspruch 1, wobei der zweite Schwellenwert im Bereich von 0,2 bis 0,6 g liegt.

Revendications

1. Procédé de détection pour un appareil électronique comprenant un boîtier contenant un module électronique alimenté en énergie électrique par un moyen de stockage d'énergie électrique, ledit module électronique incluant une unité de calcul connectée à un capteur d'accélération et à une unité de mémoire, ledit module électronique étant également connecté à un moyen d'affichage de façon à afficher des informations liées à certaines données dudit capteur d'accélération, le procédé étant implémenté au moyen d'un algorithme et incluant les étapes de :

   - acquisition de données depuis le capteur d'accélération ;
   - détection d'activités potentielles à l'aide d'un filtre passe-haut pour filtrage des données acquises de façon à détecter des changements rapides de l'accélération mesurée et à l'aide d'un filtre passe-bas pour filtrer une norme calculée des données filtrées passe-haut pour ne détecter que des activités significatives ;
   - filtrage des maxima de la norme passe-haut filtrée passe-bas au-delà d'un second seuil pour rejeter davantage d'activités sans rapport et pour déterminer un pic/une frappe de cette norme ;
   - préparation des données pour la classification, dans lequel des données d'accélération avant et après le pic/la frappe sont filtrées passe-bas à partir de données aux extrémités d'un intervalle de données centré sur le pic jusqu'aux données à la frappe, et sous-échantillonnés, en commençant par la valeur la plus proche de la frappe ;
   - passage des données sous-échantillonnées à l'étape de classification de l'algorithme ;
   - classification de l'activité qui s'est produite, par l'algorithme ;
   - caractérisation de l'activité, en se basant sur un algorithme de 1 plus proche voisin à l'aide de la norme L1 dans l'espace d'accélération sous-échantillonné.

2. Procédé selon la revendication 1, dans lequel l'unité de calcul est apte à passer d'un mode basse puissance dans lequel ladite unité de calcul sommeille à un mode normal dans lequel l'unité de calcul se réveille si le capteur d'accélération qui acquiert constamment des données avec une fréquence approximativement comprise entre 30 et 50 Hz mesure une donnée d'accélération au-delà d'un seuil déterminé.

3. Procédé selon la revendication 2, dans lequel le seuil déterminé est compris entre 1,5 et 2,5 g.

4. Procédé selon l'une des revendications précédentes, dans lequel le filtre passe-bas et le filtre passe-haut utilisent un filtre de second ordre.

5. Procédé selon la revendication 1, dans lequel le second seuil est compris entre 0,2 et 0,6 g.

Fig. 1

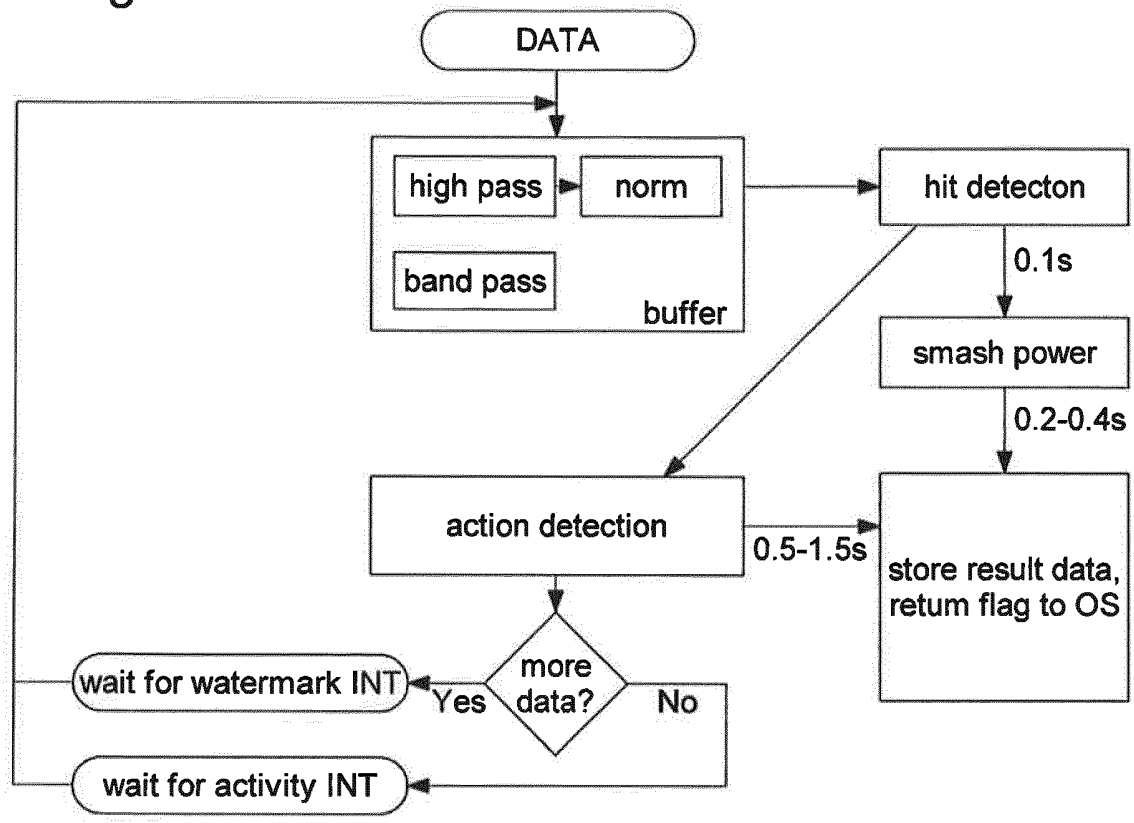

DATA
high pass
norm
band pass
buffer
hit detecton
0.1s
smash power
0.2-0.4s
action detection
0.5-1.5s
store result data, retum flag to OS
more data?
Yes
No
wait for watermark INT
wait for activity INT

Fig. 2

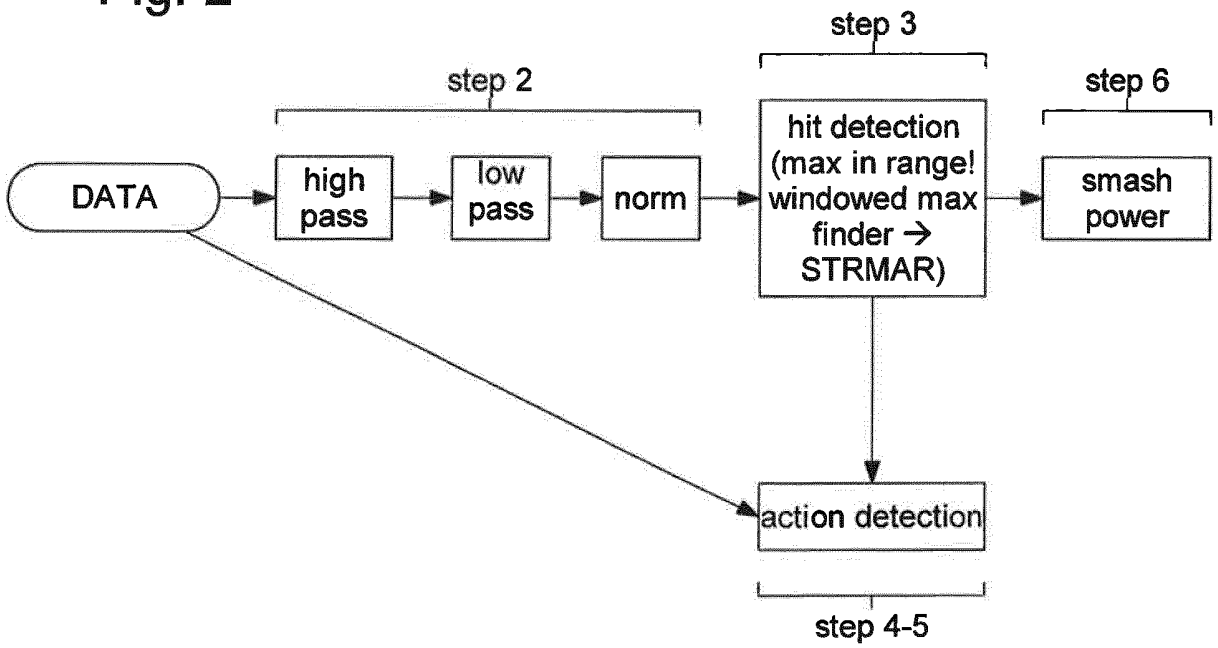
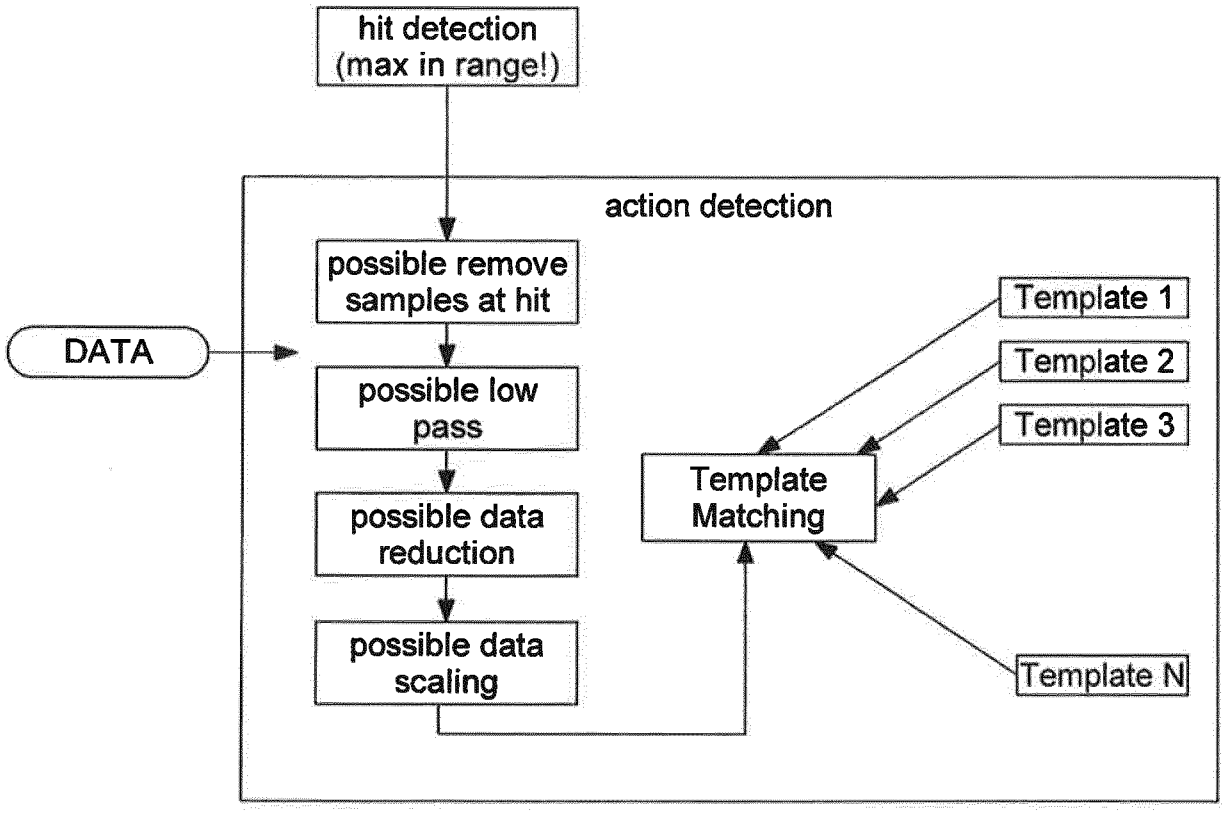

step 3
step 2
step 6
DATA
high pass
low pass
norm
hit detection (max in range! windowed max finder → STRMAR)
smash power
action detection
step 4-5

Fig. 3


hit detection
(max in range!)
action detection
possible remove
samples at hit
DATA
possible low
pass
possible data
reduction
possible data
scaling
Template 1
Template 2
Template 3
Template
Matching
Template N

REFERENCES CITED IN THE DESCRIPTION

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- US 2011196262 A1 **[0009]**
- US 6522266 B1 **[0010]**

专利名称(译)	排球技术的检测方法		
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优先权	2015178664 2015-07-28 EP		
其他公开文献	EP3123935A1		
外部链接	Espacenet		

摘要(译)

本发明涉及一种用于电子设备的检测方法，该电子设备包括壳体，壳体包含通过存储电能的方式利用电能供电的电子模块，所述电子模块包括连接到加速度传感器和存储单元的计算单元，所述电子模块也连接到显示装置以便显示与所述加速度传感器的一些数据相关联的信息。该方法包括高通滤波加速度传感器数据，低通滤波高通滤波数据的范数，然后滤波然后对数据进行低通滤波和下采样，对数据进行分类以确定发生了什么活动，并通过使用下采样加速空间中的L1范数的1-最近邻算法来表征活动。

Fig. 1

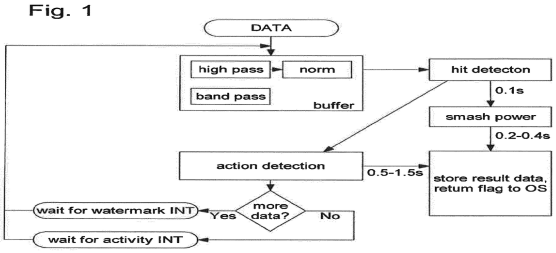

Fig. 2