PATENTS OVERVIEW
Sale of Wearables Patent Portfolio

US PAT 10,575,760	**Systems, methods and devices for activity recognition**
US PAT 9,770,179	**System, method and device for detecting heart rate**
US PAT 9,782,104	**Systems, methods and devices for acquiring and processing physiological signals**
US PAT 10,327,670	**Systems, methods and devices for exercise and activity metric computation**

THE PATENTS & TECHNOLOGY

Patent 1: EXERCISE MONITORING DEVICE WITH ACTIVITY RECOGNITION

The first patent in the patent family pertains to activity recognition using machine intelligence techniques. Several methods of recognizing activity are described. Activity recognition is based upon motion information gathered from one or more sensors mounted on the user's body. The sensors generate motion data which is processed and then passed on to a classification system to determine the activity. During this procedure the body parts positions are tracked. The patent also describes a method of detecting repetitive movement.

Sports and Fitness

The patent has wide applicability to a number of sports and fitness use cases. Human motion measurement and understanding is a critical aspect of understanding sports performance. Therefore, the method disclosed in the patent has wide applicability to any type of sport activity. The patent includes the method of

detection of repetitive movements and nearly repetitive movements. This capability is important in most sports and activities, for example running, jogging, cycling, etc. Gathering advanced motion data from the human body enables higher quality determination of metrics such as muscular performance, fatigue, hydration and calories burned. The patent discusses the method of determining activity and combining that with motion tracking, a software system that can more accurately determine exercise effort and the resulting energy expenditure.

Rehabilitation

Outside of sports and fitness the methods in the patent are applicable to rehabilitation programs. Tracking human motion during a rehabilitation program enables the medical practitioner to evaluate and assess the efficacy of the program and any adjustments or changes that may be required to improve the regimen.

Medical

The methods taught in the patent application can be used for tracking and assessment of disease progression. For example, neuro-degenerative diseases causing gait disturbances result in altered movement data which can be detected and tracked over time using the methods in the patent application. Pharmaceutical efficacy and drug interactions can be monitored and tracked over time by tracking motion data with reference to the activity being performed. The methods in the patent application therefore are applicable to pharmaceutical testing, drug dosing level determination, and long-term tracking of drug efficacy.

Augmented and Virtual Reality

Other methods in the patent will have wide applicability in augmented reality and virtual reality applications. These applications require a multitude of user inputs including human body position and motion data in order to immerse the user in a virtual world or to properly orient the user with respect to a virtual reality or an augmented reality.

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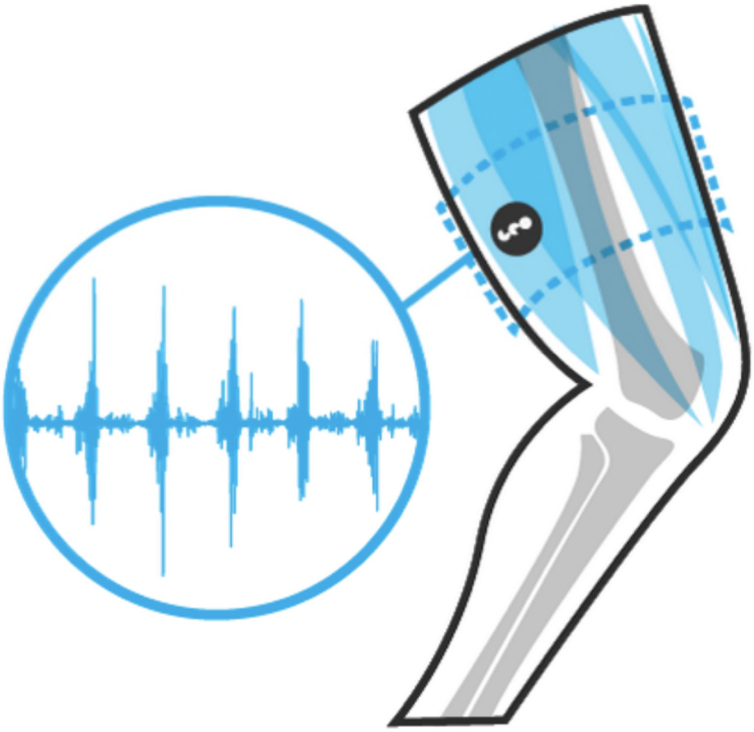
Game controller for VR. The described system can be used as the interface to a VR game. Sensors on the body will determine what full body motions the player is making. For example, was the baseball pitch a strike or not, in a VR game of baseball? By tracking body movements and recognizing the activity the system will determine the outcomes based on the data received from the sensors on the body.

Performance monitoring for sports. Imagine having a coach that can track every movement made by an athlete, even the unseen movements made by muscles. If integrated into smart textile clothing, automated activity recognition can track and evaluate performance. For example, an athlete such as a boxer who is looking to perfect punch technique can monitor every aspect of their movement, both seen, and unseen, in order to quantify and then perfect their technique.

Smart knee braces. By tracking minor variations in movement while walking, jogging, and running, people undergoing rehabilitation can be better assessed for progress. The technology could be built into an athletic knee brace and allow for the monitoring of the condition of the knee injury and its impact on the person's movement patterns. The data can be used to benchmark against movements of healthy knees.

Patent 2: SYSTEM, METHOD AND DEVICE FOR DETECTING HEARTRATE

This patent describes a method of determining heart rate from one or more sensors positioned on the body, even in the presence of other bio-signal contaminating noise. The contents of this patent application are useful if it is desirable to determine heart rate from locations on the body that are not located cross-body. Normally a heart rate monitor will electrically determine the heart rate using sensors placed on opposing sides of the body or around the chest. The patent describes how that the heart rate signal can be separated from contaminating signals such as electromyographic signals produced by muscle tissue at the sensor site using the spatiotemporal properties of the heart rate electrical signal in conjunction with machine learning and software algorithms to recognize and segment out the heart rate signal.



Heart rate is currently detected using two principal methods in existing wearables. Firstly, heart rate is detected electrically but this requires the sensors for the heart rate generated electrical signals to be placed across the body. Such a configuration is commonly found in heart rate monitoring straps worn by athletes. Secondly, heart rate can be determined from optical means by sensing blood flow in the vascular system of the human body. This is the technique used by wrist worn activity monitors that are capable of measuring heart rate. There are disadvantages to both approaches. In the first case, there is an amount of discomfort associated with wearing chest straps. In the second case, light emitting diodes are utilized for the detection process and these require considerable battery energy expenditures if used in continuous mode and as well they tend to not work well through certain skin conditions plus they must be pressed tightly against the skin. The method taught in the patent application describes a system that does not have to be located at a particular point on the body because it is able to detect heart rate signals even in the presence of other bio

signal noise sources such as electromyographic signals resulting from human motion.

Being able to determine heart rate from a limb solely using electrical signals has applications in the following areas:

Sports and fitness

Heart rate is used as a training metric across a wide range of sports and fitness activities. Heart rate is also correlated to energy expenditure and can be used to calculate the calories burned during exercise. Heart rate is a typical metric measured by heart rate monitoring devices currently found in sports and fitness equipment and common heart rate sensors on the market. The method discussed in this patent enables the heart rate monitoring device to be placed at various parts of the body that to date have not been utilized for heart rate monitoring. This is important for sports and activities that preclude the use of heart rate monitoring devices on the wrist or the chest due to interference or discomfort. As well, in the case of wearable fitness devices that are meant to track motion or measure other bio signals at the site of the heart rate sensor, it is advantageous to co-locate all of the device hardware at the same body location and therefore it is advantageous for the heart rate to be determined at the same location as other bio-signals.

Medical

The method described in the patent can be applied to active bandages such that the bandage can contain heart rate monitoring functionality. The location of the bandage can be variable and the presence of contaminating bio signals such as those produced by muscles during motion will be removed from the processed heart rate signal providing more accurate and unadulterated data sets.

Smart Textiles

The method described in this patent application can be used to implement a heart rate monitoring system that can be located in areas of the body not traditionally associated with heart rate monitoring. This will have wide applicability as smart textiles gain traction and acceptance in general use. It will be possible to place heart rate monitoring equipment within smart textiles that are not located on the upper torso or do not necessarily require sensors placed across the body. For example, heart rate monitoring could be performed within a sock or a band on the leg.

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Bandages with built in heart rate monitors. Since the heart rate can be acquired anywhere on the body, a bandage with built-in textile-based electronics can be manufactured. Bandages with heart rate readings can be used many medical scenarios that involves ambulatory patients. A fixed position ECG machine is no longer needed. It could be done with say a smart phone or similar portable device.

Smart sports apparel. There is a movement to create smart sports apparel, and at the present time the heart rate is acquired mostly from shirts with built-in heart rate monitoring circuits. This needn't be the case, and

the material in the patent describes the capability of attaining the heart rate from anywhere on the body thereby freeing the product designer to implement the heart rate monitor in any variety of smart textiles.

Off-torso stick-on heart rate monitors. There is a growing trend towards very thin stick-on wearables. Industry analysts see such devices coming out of companies like MC10. The techniques of the patent can be used to implement a stick on wearable heart rate sensor that can be located nearly anywhere on the body. This can be applicable to sports and fitness, military, and medical applications.

Patent 3: SYSTEMS, METHODS AND DEVICES FOR ACQUIRING AND PROCESSING PHYSIOLOGICAL SIGNALS

This patent describes a system, method, and device for biometric analysis using a wearable device. The device can include one or more sensors used to acquire electrical signals from the human body including electromyographic signals produced by muscles. A skin impedance capability is also described.

Wearable computing systems are an emerging category of devices. These devices enable users to perform a variety of tasks. For example, users may interact virtually with online accounts; record and/or observe information such as videos, images, and sounds; control other computing systems and other connected appliances; interact with other people; and in some instances monitor the current conditions of an individual's body.

Many devices currently available provide only minimal insights to users, for example tracking movements using inertial sensors. Devices capable of providing insight into individual physiological responses may improve the utility of such fitness tracking devices by assisting the user to improve aspects of performance, fitness, health and well-being.

Wearable devices and systems incorporating such technologies have recently been developed for a variety of

purposes. Wearable devices can be used for controlling and interacting with multimedia and other electronic devices, as well as for fitness and athletic applications. Documented in this patent are example embodiments of wearable devices, systems incorporating one or more wearable devices, and methods for biometric analysis. The systems, methods and devices described in the patent application can be applied for fitness and athletic applications such as monitoring and analyzing performance, and avoiding injury. They can also form part of a human computer interface system for virtual reality and augmented reality applications. Since activity recognition can be performed on the collected biometric data, the system described in the patent may be used for evaluation of the user's performance across a wide range of activities including sports and fitness, virtual reality gaming, rehabilitation, and medical diagnostic procedures.

The patent discusses the application of the described technology towards fitness applications but it is not limited to such applications. In the realm of fitness applications, the patent describes a system and methods which enable the discovery of which activity the user is performing as well as evaluating the performance and efficacy of the user within that activity.

In particular, the patent describes the capture of electromyographic signals and the processing of the captured electromyographic signals. These signals are very important in the analysis of human movement because they arise from the activation of human muscle tissue.

Traditional electromyographic systems require extensive skin preparation and the use of specialized sensing electrodes in order to capture the weak bio signals from the muscles. In this patent it is described how to use sensor calibration using the measurement of skin impedance so that specialized electrodes and skin preparations are not required.

As well, the patent includes how to use bio impedance measurements to monitor human body hydration

levels. This is important for both athletes and the elderly who are routinely dehydrated and in need of an early warning system in order to avoid the consequences of dehydration of muscle tissue. In athletes as we know it can severely impede performance, in the elderly it can lead to shock and many health problems.

The system discussed in the patent can be implemented as part of a smart textile or smart garment. This is described in some detail in the patent and the various configurations of the apparel including a band, a shirt, shorts, or sleeves are included.

Lastly, the overall system architecture is described in the patent. Various configurations of local processing and online or cloud-based processing architectures are described. These systems are expansible and can accommodate multiple users and different use case scenarios.

Primary application areas are sports and fitness, rehabilitation, medical monitoring, diagnostics, and drug dosing, smart textile applications, and human computer interface and activity monitoring for augmented and virtual reality.

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Sports and Fitness: Running. As an example of a sports activity that can be monitored by the system described in the patent, running is well-suited to activity recognition and muscle monitoring. A pair of shorts or running tights with embedded sensors can pick up the muscle activity and the motion of the athlete's limbs can be acquired at the same time as the muscle signals in order to provide a comprehensive view of exertion, muscle activity, and locomotion. Whether or not the muscles are activated in the optimum way can be determined. The fatigue level of the muscles can be evaluated. Cross body imbalances can be detected and the athlete can be warned of a potential injury.

Stroke recovery. In the medical arena, tracking stroke recovery by tracking motion and muscle activity will provide physicians and health practitioners with valuable data on their patient's recovery in response to the various rehabilitation protocols currently used. The system described in the patent can be built into clothing worn by the stroke victim and can provide continuous monitoring of their activity and muscle control.

AR/VR user interface. As an interface into a virtual world, the entire human body's motion should be considered. By tracking muscle activity and combining that with motion tracking, a complete picture of human body motion is obtained. This can be used to control a virtual environment or virtual user interface in upcoming augmented reality and virtual reality applications.

AR/VR sports. Virtual-reality sports are an application area expected to grow rapidly. The material described in this patent can be used for virtual reality sports. Users immersed in a virtual reality sporting events will have their motion and exertion levels continuously monitored and this will be used to evaluate the user in the context of the game or sport. In the same way, for military applications, the motion and monitoring of the soldier in the field of battle can be determined and data sent to central command to determine the performance of the solider and whether she or he needs to be relieved in the field.

Patent 4: SYSTEMS, METHODS AND DEVICES FOR EXERCISE AND ACTIVITY METRIC RECOGNITION

The fourth patent pertains to using the system described in the third patent. In the fourth patent, the acquired bio signal and motion data is used to compute activity and performance metrics. This patent comprehensively teaches various methods of computing activity metrics based on motion and measured bio signals, in particular electromyographic signals collected from muscles in the human body. A key feature that is described is the computation of activity metrics after activity recognition is performed and signal segmentation is accomplished. The material presented in the patent has wide applicability across sports and fitness, rehabilitation, medical monitoring, and military applications.

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Sports and fitness: running. Again, running is a good example of an application area for the methods described in this patent. Currently, runners train according to heart rate and steps per minute. More advanced performance indicators and training metrics can be obtained using the techniques of the patent. For example, running power can be computed. Gait efficiency can be determined. Energy inefficiencies can be determined and addressed.

Virtual reality training program. In the virtual home gym of the future, the user will exercise with the aid of virtual coaches and virtual equipment in virtual sporting arenas. Combining muscle signals with motion data gives a much more in-depth view of the effort and exertion levels expended by the participant, well beyond

the information given by a heart rate monitor.

Medical application: drug dosing and efficacy. Muscle degenerative and neuro degenerative disease progressions can be monitored in real time and continuously and used to inform physicians on treatment courses as well as influence drug dosing and timing. The data collection system can be built into clothing, wearable bands, or stick on wearables.