

# The applications of wearable technology in sporting goods

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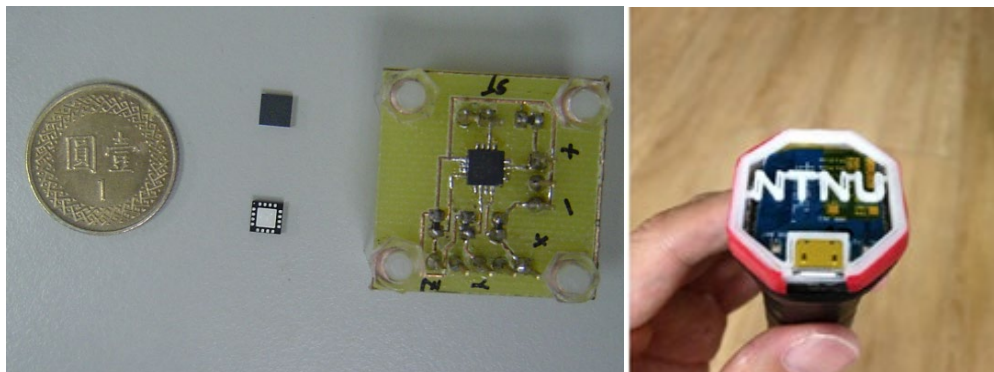
Flying with the mobile technology, mobile devices has an intimate relationship with our life. People start to use all kinds of sensors or mobile APP to record daily life, such as how many steps you walked in one day, how well you sleep, etc. Through the data quantification, all the details can be recorded and give feedbacks which may change the way of our living. With the feedback information, we know more about ourselves and feel happy which is the concept and final goal of "Quantify self". This term, quantify self, originates from the chief editors of Wired, Kevin Kelly and Gary Wolf. The first meeting of quantify self was held in San Francisco Bay Area in 2007. Apart from the sharing of "Quantify self" experiences, people get to know more about themselves via the group recognition. In 2010, this concept waves through all the major cities around the world. In Taipei, there were also similar meetings held in 2013. Everyone is writing his or her diary with numbers. Obviously, "Quantify self" has been widely recognized.

Moving with the progressive technology, wireless transmission function is also elevated and the sensor is also minimized. The range of wearable devices is much broader nowadays. The information has been diversified day by day. According to the forecast of Gartner, an international research institute, the global

production value of the wearable devices will reach 10 billion US dollars. Market Intelligence & Consulting Institute (MIC) in Taiwan also points out that its market scale of 2018 will be 14,500 million wearable devices, which will be a huge jump. The major applications of wearable devices, apart from acting as the second monitor of a smartphone, providing information and sending messages, are more persuasive in the fields of quantify self, sports leisure and health management. The global brands or enterprises like Nike, Adidas, Garmin and Google, etc. start to move into the sports industry. These signals all indicates the substantial economic values of wearable device market.

## Wearable technology

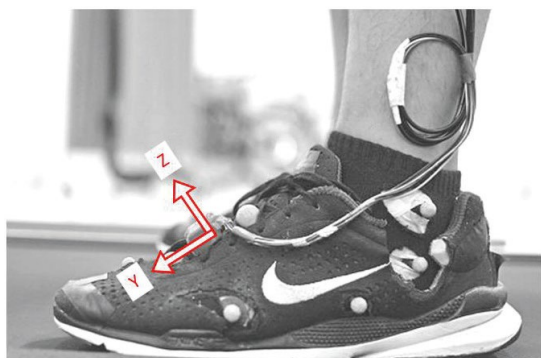
Over these years, the development of Micro Electro Mechanical System, MEMS, has entered a mature stage. Based on the theories of sports science and sports biomechanics, it is much easier to detect human movements. The human-body signal sensor measures more precisely and the size also gets smaller. Thus, it's easier to carry around and the applications in the sports science are much more common. Currently, the most widely-used sensors include the Accelerometer (see picture 1), Gyroscope, Global Position System (GPS) as well as Heart Rate monitor.



Picture 1: Tri-Axial Accelerometer (left) and wireless accelerometer model (right)

Accelerometer and gyroscope use the piezoelectric material to detect linear acceleration and angular velocity parameters in sport science and use the output magnitude of voltage as the testing result. In the recent years, these two sensors become very popular because they are applied to the well-known game, Wii. Afterwards, they are also used in the consumer electronics such as mobile phone, watches and sports bands, etc. Applying the accelerometer theory, manufacturers produce the mobile physical-activity monitoring instrument for a long period of time like Caltrac and ActiGraph. Besides, they are small and have fair prices, they do not cause disturbance upon physical activities. Therefore, they are widely used in the walking or running researches. Also, companies use tri-axial accelerometer to

produce the mobile physical-activity monitoring instrument for a long period of time like Tritarac R3D and RT3 which combines the sports data from vertical and horizontal and transvers perspectives. They can measure more precisely the levels in doing different physical activities. Gyroscope detects the angular velocity of the object and often applied in the researches of human body movement analysis and the joint angles. Besides, it is further applied in the prevention from running injuries. In use of gyroscope to observe the changing movements of the feet during running, we take these observations as the reference of fatigue and provide runners information about the potential injuries because of the irregularity of kinematical information (see Picture 2).



Picture 2: Gyroscope placed in the middle part of the feet and proceed the foot movement analysis. (This picture is from unpublished master thesis from Shih Yo (2010) who grants permission of the usage)

The application of GPS is to track the moving distance of the user while exercising. It can calculate the running paths, moving speed, accumulated time and other data. Through these data, it can exchange it into the consuming calories and other sports information and

save all these records. The signals of GPS also can work with accelerometer and provide more complete and detailed information of physical activity consumption. Over the development in these years, the intelligent mobile phone mostly installed with accelerometer and GPS, complying with suitable APP, they can measure the physical activity consumption and sports information. Moreover, they can give feedbacks and increase the motivation of the user to exercise and uplift the sense of participation.

Heart rate monitor is usually taken as the simple indicator of the exercise intensity. Athletes often use the ranges of heart rate to reach the training intensity. The user shall put it inside of the chest belt near the rib rim. And based on the changing speed of cardio muscle potential, the heart rate can be calculated. Then, via wireless transmission, the heart rate is transmitted to the wrist watch. It will be displayed and recorded (Picture 3). With regard to the heart rate, now we can see that a heart-rate watch can measure the heart rate while the user is doing sports. And a photoreceptive sensor also can calculate the heart rate by using infrared or green light to detect the blood-vessels pulses of the limbs end. The disadvantage is that the heart rate cannot distinguish the low-level and middle-level physical activities. Because of psychological pressure or the changing body temperatures, both factors would have an obvious effect on the heart rate. Besides, everyone at the same heart rate does not have the same workload. Thus, before calculating the consumed energy, the individual heart rate shall be informed, that is, oxygen consumption curve.



Picture 3: Polar M400 Heart Rate Watch (left) and H7 Heart Rate Belt (right) (<http://www.polar.com/>)

## Applications in sporting goods

The result of high tech development lead people to have a sedentary lifestyle. Without enough physical activities, the muscle strength digresses continuously. If there is no good eating habit, it would be easy to have metabolic syndromes, that is, the modern diseases. Accordingly, this will increase the social cost of the whole society. However, the occurrence rate can be significantly reduced if people change the way of their living. This is the part which health management can work on. So-called living habits modification include exercise and healthy eating. The regular exercise is what wearable sensor can assist. Based on the electronic sensor results, the user can know if exercise is effective or not. Nowadays, it is much common that exercise can improve health conditions, so not only athletes but also all the people keep doing exercise regularly. However, for most of the public, how often they shall exercise, or how to do exercise so as to achieve healthy condition, they are still the questions. Therefore, American College of Sports Medicine (ACSM) and Interactive Health Partner (IHP) combined medical treatment, fitness evaluation, sports prescription and professional counseling. It will also request the sports equipment and physical activity monitors and health monitoring instruments inspected. It provides a platform to put all the medical information of the users into the system. Meanwhile, the professionals prescribes the exercise can be also stored. It allows the users to upload their real exercise records. Then the health management experts can know all their latest physical conditions on the internet. In addition to NIKE and Adidas and other traditional industrial enterprises start to actively invest; Apple, Google, other internet electronic companies also sense the potential market values and already distribute their R&D on the sporting industry.

Apple, the well-known American brand, promotes the most eye-catching Apple Watch (Picture 4). The newly-designed sensor of the watch back, Taptic Engine, includes infrared and visible-light LED and photoreceptive sensor to detect the heart rate of the user. Together with the installed accelerometer and GPS, it can display the consumed time, distance, calories, and speed while the user is doing exercise; moreover, it can observe all different body postures such as sitting, or standing postures, etc. The graphics of the daily physical activity consumption is simplified into three circles: MOVE, EXERCISE, and STAND. Everyone can have an individual sporting goal.

Comparatively, Xiaomi, the Chinese mobile phone brand, promote the low-price sports band with an excellent CP value, Xiaomi band (Picture 5). The total is simply 5 grams, equipped with Bluetooth 4.0, military-model ADI accelerometer and three signal lights hidden under the magnesium metal panel. And ADI sensor is also used the American military caps. Due to the extreme low energy consumption, the batteries only need to be replaced once four years. It can connect with the mobile phone and show the accumulated exercise data, including the total number of steps, distance, calories, automatic monitoring of shallow and deep sleeping time span. There will be sleeping evaluation and the user can improve the sleeping quality. It does serve the purpose of monitoring the whole-day activities.



Picture 4: Apple Watch (left) and the sensor Taptic Engine (right) (<http://www.apple.com/>)



Simultaneously uploading by Bluetooth technology  
 Analysis on sporting and sleeping data and the relevant health suggestions



Picture 5: Xiaomi band and its sensor (above) and the exercise data displayed on the mobile phone (below) (Simultaneously uploading by Bluetooth technology, Analysis on sporting and sleeping data and the relevant health suggestions)

According to the recommendation by ASCM in 2011, in terms of cardiovascular exercise, people shall do exercise three to five days a week. The intensity sets the largest oxygen consumption at 45% to 90% and the maximum heart rate at 65% to 95%. The continuous exercise duration shall be 20 to 60 minutes; only then, the cardiovascular training will be effective. As to the muscle strength training exercise, people shall do it two days a week, 60% to 70% of 1 RM, eight to twelve times per set; in all, the whole muscle strength training requires two to four sets. Accordingly, we know that to monitor physical activities includes four perspectives: sporting model, frequency, intensity and duration.

miCoach SMART RUN is the personal coaching product promoted by Adidas (Picture 6). This coach is a wearable intelligent device on the wrist. Its functions cover exercise records, training, voice instruction and GPS. The major function is to evaluate the training intensity. Before using this training function, the user shall key-in the basic information and later an evaluation of the proper training intensity will come up. Also, there will be a unique individual training program. This device has the sensors like photoreceptive sensor, accelerometer and GPS. The

measurement data from these sensors will be instantly reported to the user. Later on after doing exercise, the user can upload to the computer for keeping complete exercise records. Furthermore, the user can use the statistic chart to review the progress. Because this device is equipped with the heart rate and accelerometer sensors, it can be a compact work in combination of athletic physiology and biomechanics.

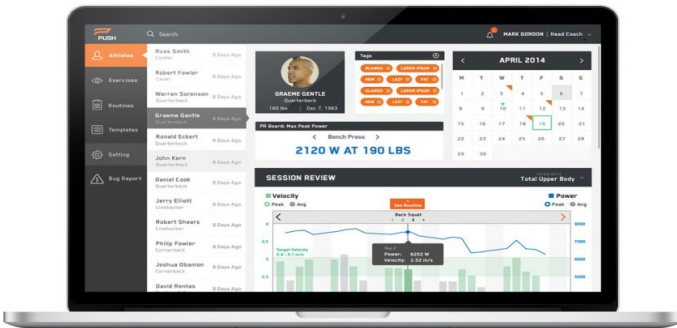
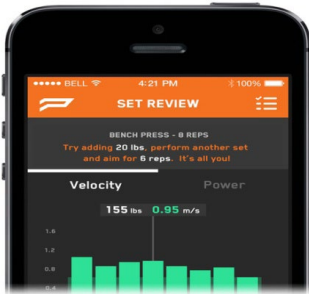


Picture 6: Adidas miCoach SMART RUN (left) and sporting data records (right) (<http://www.adidas.com.tw/>)

The above products focus on the daily life or aerobic exercise, but it cannot be useful in doing non-aerobic exercise. Therefore, the founder of Push, Rami Alhamad and his team designed this product to solve this problem. This product is installed with accelerometer and gyroscope which can detect the number to trainings, strength, work, balance, speed and tempo and other data. While using Push, the user can also use a mobile phone to choose action model and record the data. Moreover, it is installed with more than ten sports movement including deep squat, vertical lift, chin up, lift barbell, push-up and sit-up and push, etc. Push is not only a device to keep data but also a coach who can teach how much the user need to exercise more or to warn the user that he or she has reached the sport limits.

## Future trend

On the whole, the wearable devices can bring new and innovative experiences and functional applications to the public. Currently, the devices are on the initial stage. There is still a huge gap between the device and the users. For example, the battery short-time usage is the mostly complained issue. In order to develop more diversified products and get more precise exercise information, a wearable device needs to be equipped with different types of sensors like accelerometer, gyroscope, GPS, etc. which consumes more electricity. Especially in the condition of doing exercise, it needs to be recharged almost once a day. How to reduce electricity consumption and low-power consumption or battery management technology will



Picture 7: Push sensor (left), instant data upload to mobile phone (middle) and historical data (right)

become the chief challenge for the wearable devices. Another issue is the demand of minimization. At the present stage, manufacturers know how to minimize the size of the wearable device, simplify the system space and carry out more functions. In the future, how to develop lighter, thinner, and even smaller products suitable to use at various daily activities of consumers will be the question which all producers will need to face. How to upgrade the product into a simpler, lighter, thinner, long-time use device so as to make this device more common with wider acceptance. Accordingly, a wearable technology but un-sensible by human will be the future trend for the wearable devices.

The real valuable estate in the wearable devices is the "big data", the information between the device and the cloud. The most significant function of the wearable devices is the collection of quantifying data. Based on the factual

statistics and long-time accumulated big data, after they are transmitted to the intelligent clouding system, there will be a big-data analysis which provides useful information to the user. For instance, use the data collected by the sports bands and transmitted to the clouds. A team of medical professionals would give a basic health advice and further a health check or medical insurance system and other added applications. Thus, there will be great potential for the business to make profits. The governmental units can simultaneously monitor the health of all citizens. In the past, these data would be only taken for academic research institute or for the technology. At the present time, the wearable technology can present the real value and give feedbacks to the users and become sensible-information wearable technology.