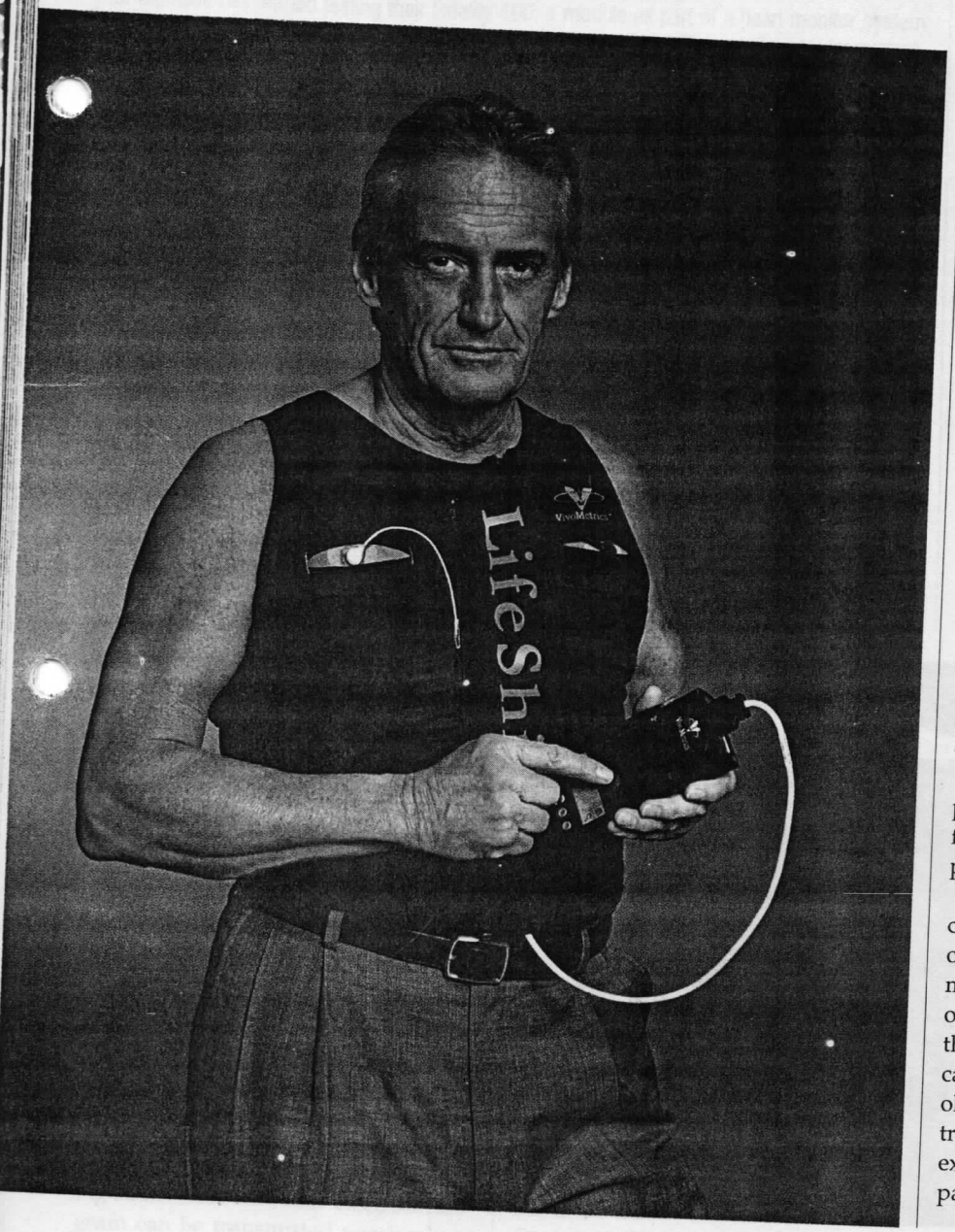
Wearable Technology Innovations in Healthcare

Ubiquitous software-driven electronic gadgets are being used for diagnosis, drug delivery, surgical operations and monitoring physiological parameters. Also they provide electronic stimulation to muscles for toning up the human body. This article gives glimpses of innovations in wearable technology for health care and medical services



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People's desire is to stay healthy during the entire course of their life. Application of technology has contributed significantly towards innovations in medicine and health-care. This is one of the many ways technology plays key role in enhancing the quality of life for all of us. Wearable technology has developed new methods of treatment and health monitoring, which have overcome the usual limitations of clinical monitoring in hospitals and treatment centres. The usual clinical monitoring at hospitals of physiological parameters such as electrocardiogram or blood pressure provides only a brief information on the physiology of the patient. The following limitations characterise such clinical monitoring:

1. They are likely to fail in sampling rare events that may be of profound diagnostic, prognostic or therapeutic importance.

2. They fail to measure physiological responses during normal periods of activity, rest and sleep, which are more realistic indicators of the health of the patient and patient response to therapeutic intervention. Even clinically based efforts to stimulate physiological stressors may fail to replicate true physiological response and such exercise may be uncomfortable for the patient.

3. Brief periods of monitoring can-

Healthcare Initiatives—An Update

Health-care cost is on the rise worldover. Park Associates's website (www.parkassociates.com/digitalhealth/interior/headlines.htm) updates people with the news from industries dealing with medical devices, health services and e-health initiatives. Some of headlines of the important initiatives read as:

1. Texas Instruments develops MSP430FG461X series of ultra-low-power microprocessor chip for development of real-time applications in medical field.
2. ALR Technologies is fielding their compliance reminder and monitoring system, which will be utilised to keep people healthier and will also reduce overall cost of healthcare.
3. Cardicom LLC announces release of their new Commander cellular telehealth device, which will be used for home monitoring of congestive health diseases, diabetes, chronic obstructive pulmonary diseases and severe asthma.
4. Alzheimer's Community Care has announced a two-year study plan to test the use of implantable radio frequency identification chips developed by VeriChip in the management of Alzheimer's patients medical records.
5. Signalife has started testing their Fidelity 100, a module as part of a heart monitor system to acquire, amplify and process physiological signals associated with a cardiovascular system.

not capture the circadian variation in physiological signals that appear to reflect the progression of disease.

Wearable technology uses miniature devices as sensors in instruments used for monitoring the health parameters of living beings. It allows clinicians to gather data where it matters. Direct observations concerning the impact of clinical interventions on mobility, level of independence and quality of life can be performed by means of wearable systems. The physiological parameters when measured through wearable technology give accurate values. It also helps in providing access to specialists in major hospitals through wireless communication and thus reduces the cost of treatment to those who cannot reach to such facilities. Wearable technologies have the following advantages:

1. Wearable technologies enable patients to carry on with their routine activities and they continuously collect information about patients' vital signs. They can transmit data to a remote monitoring location where trained technicians and physicians are there to attend on them.
2. They are miniaturised, lightweight and non-hazardous devices.
3. These are useful in early diagnosis of diseases, especially in case of children.
4. Patients who have undergone heart surgery can be helped by wearing smart shirt and their electrocardiogram can be transmitted wirelessly to hospital.
5. Persons with known disorders can wear it and be under constant monitoring.
6. Plays a critical role in disease management for a large number of individual risks such as high blood pressure, chronic bronchitis, infant and obstetrics monitoring by enabling early intervention.

The wearable motherboard (smart shirt)

The smart shirt technology can facilitate realisation of quick, safe, effective, timely monitoring of vital signs of the patient. By focusing on the human or individual bodypart as 'information node,' the smart shirt technology creates a 'patient-centered' environment while collecting information from the wearer in a timely and unobtrusive manner; this information can be used to administer treatment that is effective. The diagnosis-treatment-recovery process will be more efficient and beneficial both cost- and time-wise.

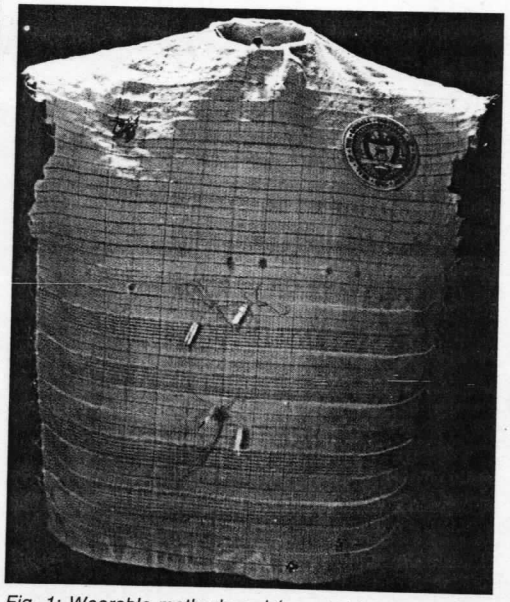

Fig. 1: Wearable motherboard (smart shirt)

Wearable smart shirt shown in Fig. 1 finds applications in battlefield, public safety, health monitoring, sports and fitness. The vital signs information gathered by the various sensors mounted on the smart shirt from the body, travels to smart shirt controller for processing; from there, the computed vital signs are wirelessly transmitted to hospital where specialists analyse it. Thus smart shirt can contribute to reductions in healthcare costs. The patients could wear the smart shirt at home and be monitored by a monitoring station at medical centre, which allows for reduction in travel and stay costs thus reducing the overall cost of health care.

Wearable photoplethysmographic biosensor: ring sensor

These are used for continuous monitoring. The ring sensor is an ambulatory, telemetric, continuous health-monitoring biosensor. Ring biosensor combines miniaturised data acquisition features with advanced photoplethysmographic techniques to acquire data related to patient's cardiovascular state. It is capable of monitoring heart beat, pulse rate, oxygen saturation, heart beat variability and cardiac output reveal. Its benefits have been realised in diagnosis and treatment of a number of major diseases like cardiovascular diseases, blood pressure, etc. In conjunction with appropriate alarm algorithms, it can increase surveillance capabilities for cardiovascular catastrophe for high-risk patients. Also it plays important role in the treatment of chronic diseases, by providing information that enables precise titration

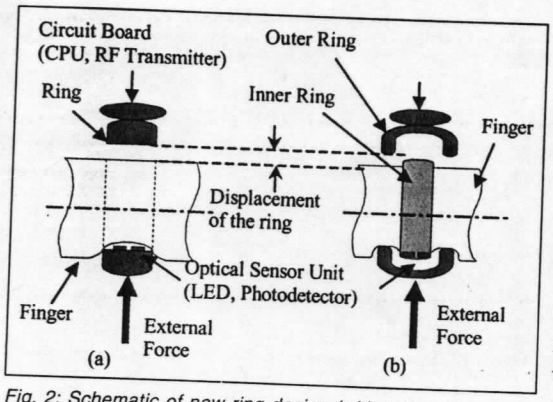

Fig. 2: Schematic of new ring design (with and without external force)

of therapy or detecting lapse in patient compliance. On a daily basis wearable ring sensors could detect a missed dose of medication by sensing untreated elevated blood pressure and could trigger an automated reminder for the patient to take the medication.

Ring sensor has many configurations for use. Central to the ring sensor design is the importance of long-term wearability and reliable sensor attachment. Since continuous monitoring device mat must be non-invasive and worn at all times, a ring configuration for the sensor unit is a natural choice. Because of the low weight and small size, they are more often used. Recent studies have indicated finger as one of the best place for attachment of WBS. The primary vasculature of the finger is located near the surface and therefore makes it optimal for monitoring arterial blood flow using non-invasive optoelectronic sensors. Thus ring is ideal for long-term measurements.

The typical waveform of photolethysmograph signal obtained from human subject at rest comprises a large segment of DC signal and a small amplitude of AC signal. The DC component of photon absorption results from light passing through various non pulsatile media including tissue, bones, blood veins and non-pulsatile arterial blood.

The relative location of LED and photodetector in the finger is an important design issue determining signal quality and robustness against motion artifact.

Fig. 2 shows the configurations of ring sensor.

The LEDs and photodetectors are placed on the flanks of the finger rather than the dorsal and palmar sides. These locations are desirable for two reasons: both flanks of the finger have a thin epidermal tissue layer through which photons can reach the target blood vessels with less attenuation and digital arteries are located near the skin surface parallel to the length of the finger.

It should be noted that arterial pulsation is not only greater in magnitude than cautious pulsations but is also less susceptive to the motion due to the natural higher internal pressure. While the capillary collapses with small external pressure of the order of 10-30 mm Hg, the artery can sustain external pressure up to 70 mm Hg. Therefore light static load, such as contact with the environment, may not disturb the arterial pulsations. For these reasons at least one optical device either photodetector or LED should be mounted on the lateral face of the finger near the digital artery.

Wearable cardioverter defibrillator

The wearable cardioverter defibrillator (WCD) is a microprocessor-based and programmable patient-worn device that is designed to sense cardiac function and automatically deliver electrical therapy to treat ventricular tachyarrhythmias. The device is to be worn continuously by the patient, as its purpose is to continuously monitor the patient's electrocardiogram (ECG) and to detect life-threatening ventricular tachyarrhythmias, specifically ventricular tachycardia (VT) and ventricular fibrillation (VF). If the WCD device detects VT or VF above a programmable preset rate, it is capable of delivering a defibrillating pulse to the heart through the therapy electrodes in an attempt to restore an effective rhythm.

Wearable cardioverter defibrillator is a new treatment option for sudden cardiac arrest that offers patients advanced protection and monitoring as well as improved quality of life. It is an external device that is intended to perform the same tasks as an automatic implantable cardioverter defibrillator (AICD), without requiring any invasive procedures. It consists of a vest that is worn continuously underneath the patient's clothing. Part of this vest is the 'electrode belt' that contains the cardiac monitoring electrodes, and the therapy electrodes that deliver a countershock. The vest is connected to a monitor with a battery pack and alarm module that is worn on the patient's belt. The monitor contains the electronics that interpret the cardiac rhythm and determines when a countershock is necessary. The alarm module alerts the patient to certain conditions by lights or voice messages.

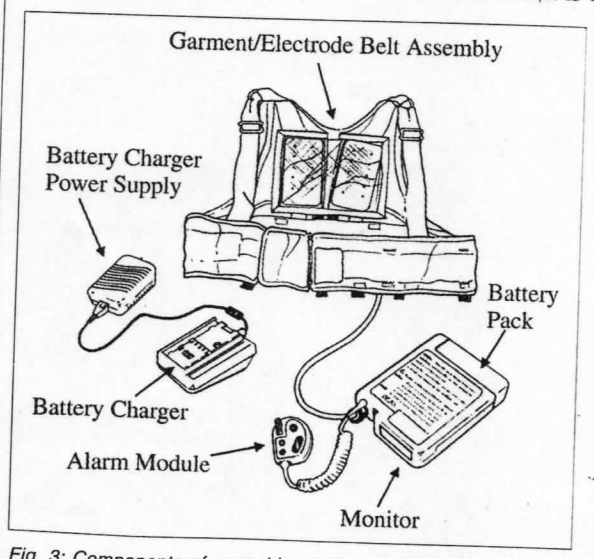

Fig. 3: Components of wearable cardioverter defibrillator

The current-generation device uses a monophasic truncated exponential waveform with a maximum energy output of 285 Joules. The WCD shown in Fig. 3 consists of a chest garment with installed ECG and shocking electrodes and an alarm and monitoring patient interface unit.

The WCD constantly and automatically checks the patient's heart

rhythm with electrodes on the chest, in the same way as a doctor or technician takes an electrocardiogram (ECG). If it detects an abnormal heart rhythm, it displays a message for the patient to press and hold two response buttons to prevent the treatment shock. Receiving a shock when conscious is painful. If the device continues to detect the abnormal rhythm and the patient loses consciousness, the patient involuntarily releases the response buttons. Once the buttons are released, the WCD device now 'knows' that the patient is in danger, so it automatically delivers electrical shock therapy to restore the heart rhythm to normal.

Wrist blood pressure monitor (auto-inflation)

Wrist blood pressure monitor as shown in Fig. 4 is a wearable device and thus enables the patient to measure his blood pressure at convenient time at home or even during office hours.

It is easy to use, accurate and displays clear digital measurements. Wrist blood presure monitor technology is based on the 'oscillometric method.' The term 'oscillation' refers to the measure of vibrations caused by the arterial pulse, and is a non-invasive method to determine blood pressure. It is mercury-free, light-weight and compact.

Butterfly abs

Obesity is one of the main reasons of major diseases like cardiovascular, diabetes, blood pressure, etc. Nowadays people are busy with various activities and do not get time to take regular exercise to maintain their body shape and weight. Therefore they have to take help of a device, which reduces their body weight without disturbing regular work. However, to maintain shape of their body it is necessary to undertake regular additional exercise.

Butterfly abs consists of electronic muscular stimulator (EMS). While using EMS, the brain sends a nerve impulse to the 'motor point' of muscles. This signal is a message to the muscles to expand and contract. Electrodes are placed over the motor points of the muscle group to be exercised. The stimulation is applied through the pads, the signal finds its way to these motor points and causes the muscles to expand and contract. This action makes it possible to duplicate a conventional exercise, similar to an isometric exercise. During the exercise, the brain is controlling muscles. Electrical muscle stimulation uses an outside electrical source that stimulates the nerves to send signals to muscles to expand and contract. Sending electrical current through self-adhesive electrodes placed over the muscles does this. The current passes through skin to the nerves in that area, causing muscles to expand and contract. Normally when one performs an exercise, his brain sends a message through spinal cord to nerves indicating muscles to contract. EMS uses electrical impulses to stimulate the nerve axons. These impulses reach the nerve axons, signaling the muscles to contract and relax rhythmically as instructed by the EMS unit. EMS actually stimulates muscles that you can not normally exercise voluntarily. This allows you to train muscles that may normally have little activity. Butterfly abs is designed to stimulate muscle motor nerves and has the following features:

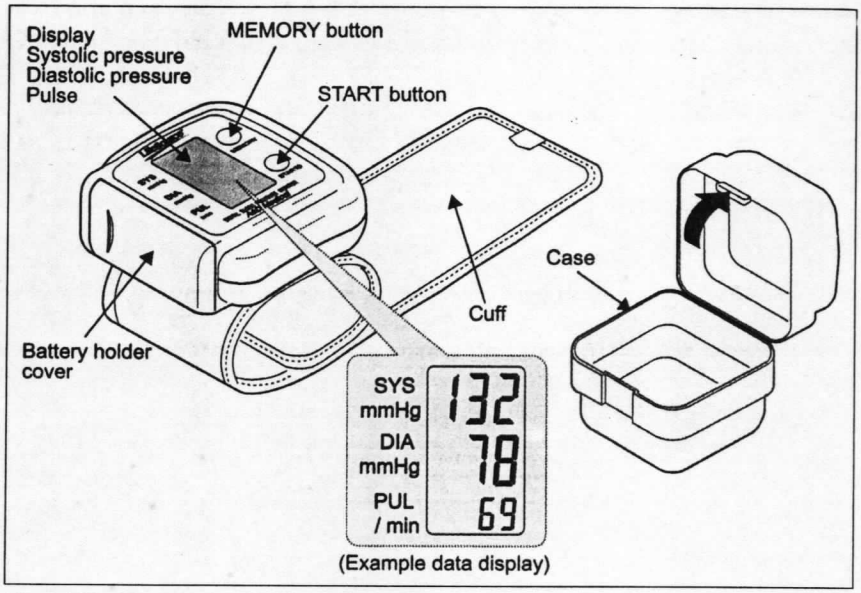

Fig. 4: Wrist blood pressure monitor

1. This system targets hard-to-reach body parts.

2. Butterfly abs are portable, light-weight and compact EMS system.

3. It delivers electronic pulses to muscles.

4. It is sleek, ergonomic and high-tech gadget.

5. It offers up to 800 body contractions in minutes for rock-hard abs.

6. It has five programmes of exercises with 10 levels of intensity.

7. Tones and develops shapely muscles in abdominal, tummy, buns, hips, legs and thighs regions of body.

8. It does not require messy gels.

To sum up

Wearable electronics is most beneficial for the areas where the medical services are not available at a short notice and hence it is boon for them. Many people are greatly involved in the work of developing wearable artificial kidney and wearable artificial lung. Thus wearable technology greatly overcomes ambulatory monitoring limitations and helps in early diagnosis of the diseases. It is here for the benefit of people worldover. ●

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