WEARABLE PRODUCTS FOR HEALTH & ENJOYMENT AND ENERGY HARVESTING

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Introduction

A device is considered wearable if:
- Device is worn for extended period of time
- User inputs and control possible
- Enhancement of user’s experience

A wearable device may include one, two or all three functions:

Attributes of Wearable Computers:

- **Hands-Free**
  - Voice / Gesture Controlled
  - Development Platform
  - Always On
  - Environment-Aware
  - Connected
- **Low Power Consumption**
  - Instant Wake
  - Background Working / Sensing
- **GPS**
  - Accelerometer
  - Camera
  - Microphone
  - Other Sensors
- **3rd Party apps**
  - API Partners
- Less distracting when receiving alerts / reminders / messages
- Wi-Fi
- 3G / 4G
- Bluetooth
- NFC (Near Field Communication)
Wearable technology, wearables, fashionable technology, wearable devices, tech togs, or fashion electronics are smart electronic devices (electronic device with micro-controllers) that can be incorporated into clothing or worn on the body as implants or accessories, such as the smartwatch and activity tracking devices such as the “Fitbit”.

Their value is that they are made with electronics, software, or sensors, which gives them the ability to connect to other devices that let them exchange data (including data quality through the internet) with a Medical Provider, without requiring human intervention.
Wearable Devices – Current Users

Six Distinct Profiles of Wearable Technology Users:

**Curious**
They are ‘Playing’ with these devices.

**Controller**
Will purchase a device only when that it will do what they want it to do.

**Self Medic**
Uses devices to control own health and well-being. Often a super-user, using Multiple accounts to get accurate account of health.

**Quantified Self**
‘Zoomed in’ focus on tracking themselves not just for diet or health, but for academic purpose.

**Finish Line Fanatic**
Really excited at the adoption stage, but shine wears off when realize device needs to be calibrated, charged, synced, etc.

**Ubiquitous Future**
Digital Natives that will grow up with the next generation of wearable technology.

*Source: The Human Cloud, Rackspace, June 2013*
Why Wearables?

- Quick and Easy access to Information
- Reliable and Immediate
- Rare that you will misplace it
- Consolidation
- Enhances and Empowers the wearer
- Increases Engagement with the Environment
- Can help in Multitasking
- Private for the user – Discrete if wanted
SPO2 IS A BLOOD OXYGEN SATURATION SENSOR
ANATOMY OF A WEARABLE TRACKING DEVICE

#quantifiedself
Key attributes of wearable tech products

- **Hands-Free**
  - Voice / gesture control

- **Development Platform**
  - 3rd party apps
  - API partners
  - Accessories

- **Attention-Getting**
  - Less distracting when receiving alerts / reminders / messages

- **Always-On**
  - Low power consumption
  - Instant wake
  - Background working / sensing

- **Environment-Aware**
  - GPS
  - Accelerometer
  - Compass
  - Camera
  - Microphone
  - Other Sensors

- **Connected**
  - WI-FI
  - 3G / 4G
  - Bluetooth
  - NFC

WHAT AREAS ARE WEARABLE DEVICE USED FOR?
FROM HEAD TO TOE WEARABLE TECHNOLOGY

**SHIRT**
Conductive thread means a computer is literally built into the fabric of the shirt, providing the processing power for all the other wearable gadgets.

**WRISTBAND**
A sensor that tracks movement to determine the number of steps taken through the day - 10,000 is ideal - and how much sleep the wearer gets at night.

**GLASSES**
Overlays navigation directions and information about points of interest directly on to the wearer's field of vision.

**WRISTWATCH**
Vibrates when a message arrives and displays it on the watch face. Tells the time too.

**HAND**
Embedded under the skin is a chip containing medical records, passport data and credit records. Information is transferred by waving the hand over a suitable scanner.

**TROUSERS**
Also made with conductive thread, the trousers take the energy generated by movement and use it to power the other gadgets.

**SHOES**
GPS chip provides directions using LED lights in each shoe: the left shoe indicates direction, while the right shows distance.
Preferred Locations for Wearable Technology

- Glasses: 55%
- Headband: 19%
- Armband: 40%
- Wristband: 65%
- Coat: 26%
- Shirt: 31%
- Shoes: 20%
- Hat: 20%
- Contacts: 20%

Source: SSI
Specifications

Connectivity
5G Network and Wi-Fi 902

Camera
Hidden 16 megapixel camera

Built-in Speaker

Built-in MIC

Memory
RAM - 4GB
Internal Memory - 32/64GB

Sensors
Palm-Rec, Thermometer, Accelerometer, gyro, proximity, compass, barometer, RGB ambient light, Gesture(IR), Heart Rate Sensor

3 inch flexible UHD Super Emo-LED display

Thickness
0.2mm

S Laser (Hidden Beam Projector)
Resolution up to 1920*1280

Weight
1g
A look at the fast evolving gadgets in Fitness, Wellness & Health care

Continuous Glucose Monitoring - monitors and retrospectively review patients glucose

Fitness and Heart Rate Monitor benefits in training aerobically & understanding heart rate

Fuel band – tracks & measures everyday movement

Sleep Sensor - tracks your sleep

Sensory Fitness Socks - sensors communicate with bluetooth-powered anklet all feeding data to your smartphone

Foot Pod Pedometer measures speed, distance travelled and pace
What's the Future of Wearable Technology?

Google announced it’s releasing a Software Development Kit (SDK) for Android-powered Wearables

iWatch, secures solar touchscreen patent

Looxcie has released live streaming wearable headset with live-feed access from a proprietary tablet and smartphone app
Sensible Baby that fits into a chest pocket and sends information and active alerts on temperature, baby orientation and breathing to a parent's mobile device

Sensory Fiction (MIT Labs) in which reader will soon experience physical sensation while reading the written words

Smart Contact Lenses, which can help measure glucose level in tears

Disney's MyMagic+, is capable of monitoring visitors and collecting data about their behaviour in Disney World theme parks
Create New Realities
For people who go to Disney World, **MagicBands and cards** are secure all-in-one devices that allow you to effortlessly access the plans and vacation choices that you’ve made with “My Disney” Experience.

They are colorful, waterproof wristbands—resembling a watch or bracelet—that you can quickly and easily touch to a sensor called a touch point.

Cards work in a similar fashion, but physically resemble a plastic credit card or driver’s license. Both MagicBands and cards allow you to travel lighter throughout your vacation.

**They both work as RFID (Radio Frequency Identification) devices.**
You can use your MagicBand or card to unlock the door of your Disney Resort hotel room.

Enter theme and water parks (with valid admission)

Check in at [FastPass+] entrances.

Connect Disney PhotoPass images to your account.

Charge food and merchandise purchases to your Disney Resort hotel room (only available during your hotel stay).

A MagicBand can also add a touch of magic to your vacation by unlocking special surprises, personalized just for you, throughout the Walt Disney World Resort!
Google's Pixel Buds are earbuds that connect to a smartphone--in this case, the Pixel--via Bluetooth. At $159, they are the same cost as Apple AirPods so they both can play music or other programs but **Google’s headphones can do something Apple's headphones can't do: Translate up to 40 spoken languages, in real time!!**

The operation is performed using Google Translate, which is built into the Google Pixel. The wearer taps the right earbud and says something like, "Help me speak Spanish," and Google gets to work.

A person standing nearby can speak out loud in Spanish, and the earbuds will give the wearer the English translation in her ear.

They can then hold down her right earbud and speak in English, and her phone will project the Spanish translation from the Pixel's speaker. The live translation begins only a second or two after the person stops speaking.
Taking wearable technology to the nth degree, Google X Lab unveiled a contact lens specifically designed to track diabetics’ blood glucose levels, using a tiny wireless chip and a miniature glucose sensor.

These electronics are embedded between two layers of a soft lens material. Thus far Google says it has tested prototypes that can generate a reading once per second.

In the future, the lab plans to integrate LEDs within the unit that will alert the wearer when glucose levels cross above or below certain thresholds.
Express Ourselves in New Ways
Future Outlook

Wearable Devices should be developed since they enhance the user’s lives, and not just due to the easier availability of the required technology.

- Developed ecosystem
- Standalone Wearables have a potentially larger market
- Currently Smartphone act as a hub for Wearable, which limits penetration of Wearables (that are priced lower)
- Reduction in the overlapping nature of Wearables and Smartphones
- Privacy concerns will be addressed soon
- Consumers aged 16-24 most likely to adopt this technology first (Always On, Always Connected Generation)

Short Term Outlook
- Increase in competition and entry of established brands (mainly in proven markets).
- Increase in innovation from start-ups.
- Crowdfunding will continue to be popular.
- Emergence of workplace wearables.

Medium Term Outlook
- Explosion of Medical Wearables- To assist doctors with diagnosis
- Addition of gamification
- Move from Inertial Measurement Units (inaccurate) to Heart Rate Monitors and Temperature Sensors in the Fitness Devices (Can’t place multiple sensors on body)

Long Term Outlook
- Devices will evolve to be a passive entity alongside humans, its presence will become unnoticed.
- Implantation will become possible and advantageous.
- Life expectancy will increase a lot since we will identify and treat diseased at an early stage.


*Source: Tech crunch, Jan 16, 2014

Google has patented a Smart Contact Lens
ENERGY HARVESTING

energy harvesting

- thermal energy
  - body heat
  - external heat

- radiant energy
  - solar energy
  - RF fields
  - RF waves

- mechanical energy
  - body motion
  - heel strikes
  - vibrations
  - air flow
  - blood flow

Types of Energy Harvesting

Thermal → Micro
Vibration & Motion → Micro
Solar → Macro & Micro
Wind → Macro
Energy harvesting (also known as power harvesting or energy scavenging) is the process by which energy is derived from external sources (e.g. solar power, thermal energy, wind energy, salinity gradients, and kinetic energy), captured, and stored for small, wireless autonomous devices, like those used in wearable electronics and wireless sensor networks.

Energy harvesters provide a very small amount of power for low-energy electronics.

# COMPARISON OF ENERGY HARVESTING TECHNIQUES

<table>
<thead>
<tr>
<th>TYPE OF ENERGY HARVESTING</th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
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| **THERMOELECTRIC**       | 1. No moving parts allow continuous operation for many years.  
2. Thermoelectrics contain no materials that must be replenished.  
3. Heating and cooling can be reversed  
4. No separate external voltage source is needed | 1. Thermoelectric energy conversion has low efficiency for small thermal gradients  
2. Irreversible effects in thermoelectric materials limit their efficiency and economy for power generation applications  
3. Seebeck coefficient can currently not be increased beyond a necessary limit |
| **ELECTROMAGNETIC**      | 1. No separate external voltage source is needed  
2. No mechanical stops are needed  
3. No smart materials are needed | 1. Maximum voltage obtained is only 0.1V  
2. Bulky size  
3. Difficult to integrate with microsystems  
4. Difficulty in fabricating coil |
| **MAGNETOSTRICTIVE**     | 1. High Coupling coefficient  
2. No depolarization occurs  
3. High flexibility  
4. Suitable for high frequency processes | 1. It is a non linear effect  
2. Pick up coil is needed  
3. Bias magnets are needed  
4. Difficult to integrate with micro-systems |
| **ELECTROSTATIC**        | 1. Easier to integrate with microsystems and electronics.  
2. Voltages of 2-10V are obtained  
3. No smart material needed | 1. Separate voltage source is sometimes needed  
2. Mechanical stops needed  
3. Capacitance causes damping which needs to be reduces motion |
| **PIEZOELECTRIC**        | 1. Voltages of 2-10V are obtained  
2. No mechanical stops needed  
3. High energy density  
4. No separate external energy source needed  
5. Compatible with micro-fabrication | 1. Microfabrication process not compatible with standard CMOS processes  
2. Piezo thin films have poor coupling coefficient  
3. It has depolarization and ageing problems  
4. Charge Leakage and high output impedance  
5. PZT is brittle material |
Overview of the State of the Art of Energy Harvesting Technologies

- Lightning Packs Energy Harvesting Backpack (16 W)
- Self-winding Wristwatch (5 μW)
- SRI Shoe Energy Harvesting Shoe (400 mW)
What is currently being done in Canada

Bionic Energy Harvester
- 1.2 kg total (0.6 kg per leg)
- Comfortable
- 5-7 Watts without effort
- >10 Watts with effort
- Generative Braking
- SmartGen

Power & Control Module
intermittent & variable power input
efficiently charge Li-ion or Nickel–Metal–Hydride (NiMH)
Harvesting Human Movement

- Several possibilities that do not excessively burden the wearer

- Backpack Suspension and Padding: 0.5–5w
- Limb Swing: 0.2–3w
- Chest or Torso Expansion From Breathing or Routine Movement: 0.1–1w
- Hand or Leg Cranked Generator for Emergency Back-up (Short-term): 10–100w
Enabling a Heel-strike Generator

- Energy from the heel strike is “free” - it would otherwise be dissipated as heat
- Energy converted per step with reasonable heel compression can be up to 5 Joules
- Power generated (both feet) during walking is 1W to 10 W
- The amount of electro-strictive polymers needed to convert 5 J is less than 50 g or 50 cc.
- Electromagnetic or piezoelectric devices would weigh more than 10 times this weight

* - EAP – Electro Active Polymer
DARPA Heel-strike Generator

- Developed a heel-strike generator to capture free energy while walking
- Demonstrated up to 0.8 J per heel strike
- Developed multi-layer polymer fabrication techniques
  - Demonstrated a 15 layer device

Heel-Strike generators are expected to produce 1W of power under normal walking conditions
Applications of a Heel-strike Generator

- Boot generator can assist the dismounted soldier in several distinct ways:
  - Power source or battery recharger to reduce battery weight for a mission
  - Smart Shoes, Multifunctional Footwear - simplify logistics by reducing the number of separate batteries or devices required
    - power an instrument that should logically be located in a boot for best operation:
      - personal navigation system, medical status monitor, foot warmer
    - power a device that could be located in a boot for weight or space savings
      - Friendly ID beacon, comm link, magnetometer, chem/bio detector, special battery or capacitor for high-voltage device such as a night vision scope
  - Dynamic Footwear - Actuation or Adaptability for enhanced performance
    - reduced injury
    - improved comfort
    - more efficient load carrying
PVDF

• In 1961 Polyvinylidene Fluoride, a piezoelectric plastic was invented. It is one of the most widely used piezo-polymer from which substantial electricity can be generated.

• It is cheap and physically quite strong.

• In 2001 researchers found that PVDF becomes supersensitive to pressure when impregnated with very small quantity of nanotubes, thus PVDF with its inherent superior mechanical properties when upgraded with nano-technology, produces a new generation of piezo-polymers, which are durable and can generate large quantities of electricity economically.
Capitalizing on the friction and heat created by walking, running and even just wearing jeans, engineers from Michigan Technological University, Arizona State University and NanoSonic Inc. devised a way to use this type of generated energy in a concept backpack that can charge portable electronic devices, like iPods and mobile phones.

Shoulder straps made of Polyvinylidene Fluoride (PVDF), a strong, flexible material that feels similar to nylon, are piezoelectric, which means that an applied stress generates an electrical charge.
Piezoelectric materials are materials that produce a voltage when stress is applied. Since this effect also applies in the reverse manner, a voltage across the sample will produce stress within the sample. Suitably designed structures made from these materials can therefore be made that bend, expand or contract when a voltage is applied.
Recently, electrical engineers at the University of Michigan, have perfected a device that can harness ambient, mechanical vibrations and convert these into electricity at 5 to 10 times the efficiency and power output than previous devices of this type. At 27 cubic millimeters, a single such system fits — with room to spare — on a penny.

The devices actually “scavenge” energy from their local environment in the form of cyclic vibrations from the factory machines they touch. The devices make use of the *piezoelectric effect* which is produced by crystalline structures that generate an electrical charge when subjected to mechanical strain or pressure.