MEMS: Sensing a New World of Applications in Healthcare and Wellness

Jay Esfandyari
MEMS Product Marketing Manager

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Health and Wellness
More than one billion adults overweight worldwide

“Worried well” vital sign monitoring:
- Weight
- Blood pressure
- Glucose
- Cholesterol
- Activity level

Benefits:
- Monitor and motivate
- Achieve individuals’ goals
- Access personal fitness information anywhere
- Enhance trainers’ services
Disease Management
More than 900 million chronic disease patients world wide

- Chronic disease
- Post trauma
- Pre-op

Vital sign monitoring: (remote patient monitoring)
- Diabetes
- COPD
- CHF
- Hypertension

Benefits:
- Provide better-coordinated care
- Connect to care team
- Empower individuals
- Encourage early detection
- Reduce costs

Blood-pressure Cuff
Pedometer
Weight Scale
Fitness Equipment
Medication Tracking
Glucose Meter

Cell Phone
PC
Personal Health System

Digital Home

Internet

Family Care Givers
Disease Management Service
Healthcare Provider
Personal Health Record
Aging Independently
More than 600 million elderly individuals worldwide

Basic life monitoring:
- Bed pressure (sleep)
- Bathroom sensor
- Gas / water sensor
- Emergency sensor

Benefits:
- Involve family members
- Allow remote analysis & care
- Provide integrated view
- Encourage early detection
- Reduce costs
MEMS technology can be used to produce geometrically well defined, highly reproducible structures and surfaces area.
Advantages of MEMS

- MEMS technology is mainly based on silicon, which interferes less with body tissues
- Small size, high functionality, high precision, accurate, low cost, low latency, high level of integration, low power consumption,…
- High volume production capability can significantly reduce cost
- Multiple components can be integrated on a single chip
- Smaller volumes of reagent samples for analysis are possible
- Less painful as they are less invasive
- Long battery life due to ultra low current consumption.
Challenges of MEMS

- Packaging, fabrication processes and materials remain the biggest hurdle for MEMS medical devices:
  - Bio-compatibility: the device should be benign and non-toxic to surrounding tissues.
  - Hermeticity: The device environment is usually harsh and the reactions should be minimized or reduced. E.g. Blood is considered highly corrosive.

- Long time from proof of concept to prototype and then through FDA approval
- Life of the device
- Retrieving data from the device
- Resist drifting along with the body fluids
Physical Sensors

- Accelerometer
- Gyroscope
- Magnetometer
- Microphone
- Pressure Sensor
- Strain Gauge
Biosensors and Biochips

- **Diagnostics & Monitoring**
  - Bio-chemical Sensors
  - Glucose Sensors (CGM)
  - Contact Lens Sensor
  - Sensor in extreme environmental

- **Molecular Diagnostics**
  - LabOnChip™
    - Vere Flu
    - Vere Foodborne
    - Vere Threat
    - Vere MTB-MDR
    - Vere Trop
    - Vere FingerPrint
  - Real-time PCR

- **Therapeutics**
  - Infusion: Micro-fluidic MEMS for Drug delivery
    - Transdermal uNeedles
    - Injectable
    - Implantable
    - Diagnostics

- **Personal Care**
  - Home care
  - On-Site Patient monitoring
MEMS Enable a World of Applications

**Sensors:**
- pH, humidity, Oxygen, CO2, Blood gas analysis, Continuous Glucose Sensors, Other chemicals

**Applications:**
- Respiratory equipment
- Bio-reactors, agriculture
- Toxicants detection
- Food monitoring
- ECG (Analog)
- Glaucoma Lens (MEMS)
- Insulin Nano pumps (MEMS)
- Lab-on-Chip (MEMS)
MEMS Accelerometers

- **Accelerometer** is a system based on **silicon mechanical structure** able to sense **motion**

- Physical activity monitoring

- Involuntary hand motion (Parkinson’s disease,..)

- Adjusting stimuli levels in pacemakers
Man-Down Solution

• Based on a 3D digital accelerometer and a digital pressure sensor

• Sensor fusion algorithms help to reduce false triggering of rescue calls

• The algorithm, optimized for sensors placed on the belt or at waist level, is very light and designed to be executed on low power computational systems.
Disposable Sensor for Early Diagnosis of Glaucoma

- Strain gauge & antenna embedded in a silicone contact lens
- The Sensor is capable of measuring cornea deformations due to Intra-Ocular-Pressure (IOP) variations
- The IOP Sensor is a wireless sensor that acts as a transducer, antenna and mechanical support for additional read-out electronics
- Triggerfish™ System has been developed by SENSIMED AG.
- Application: Contact Lens for early diagnosis and treatment of Glaucoma

The complete (Smart) System commercialized by SENSIMED includes:
- Contact Lens
- External antenna & data-cable
- Recorder
- Software
BodyGuardian – Preventice Solution

• Medical device and mobile health solution to prescreen and actively monitor abnormal heart conditions.

• Mayo Clinic research and clinical trials

• Monitors EKG, heart rate, breathing rate, activity level, and body position

• Use case – combine with medication management for 30-45 day remote monitoring of coronary stent patient

• Future use cases for fitness oriented people as mobile comprehensive heart rate monitor

Captured Medical Information for Physicians and Medical Professionals with iPad
Sensors for Activity Monitoring

• Human body tracking using sensor fusion:
  • fall-detection of senior people
  • golf swing motion capture
  • sports collision detection

• Sensors can be used to track human body motion:
  • head movement
  • arm or leg movement
  • body jump
  • twist motion, etc.

For example: This can be used to model the gait of a person for dead reckoning development.
Body Area Network – New Trend

Products
• High-Performance MEMS Accelerometers, Gyros, Pressure Sensors, uPhone, Strain Gauge
• RF Transceivers
• Analog precision human interface, e.g.: ECG
• Low power uC/MCU
• Power Mgmt, Signal condition, Thin Film Battery

Benefits of MEMS-based Solutions:
- Accuracy of Sensors
- Non-Invasive Technique
- Low Cost for Public Healthcare Service
- 24h Monitoring

Addressing the needs of an aging population

Lowering healthcare system costs

Low power, Battery Operated Energy Harvesting

Body Area Network

Insulin-Pump System

Vital-Sign Monitor ECG

Sensor Network: Sensors will talk to each other

Ergonomically “Friendly” Band-Aid type patch

Glaucoma Sensor

Sensor Node 1

Sensor Node 2

Sensor Node 3...
Tele-Health – Remote Monitoring

- Tele-Health, Remote Patient Monitoring, Home Health, Personalized Medicine, Tele-medicine….

  - Continua/Connectivity Driven (USB, BTLE, BT); ECG & Holter Monitors; Breathing Rate; Activity Level; Body Position; Temperature; Blood Testing

- Continua Health Alliance “Interoperability”

Aging population

- Keep people out of the hospital

- Care Server

- Internet

- ADSL

- Doctor/User PC

- User IP Box

- Off-body sensors

- Bluetooth

- GPS location

- Band-aid or T-Shirt

- Off-body sensors

- Bluetooth

- DUN

- GPRS
Looking Ahead

MEMS will continue to grow fast and enable a revolution in Healthcare

- Advanced Technologies & Design
- Best-in-Class Manufacturing
- New Applications

THANK YOU