3D Accelerometer MEMS in a Context of Gaming and Healthcare

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IEEE Meeting

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Kionix, Inc.

Kionix is in the business of silicon micromachining (MEMS)

- IC manufacturing techniques are used to sculpt three-dimensional silicon devices

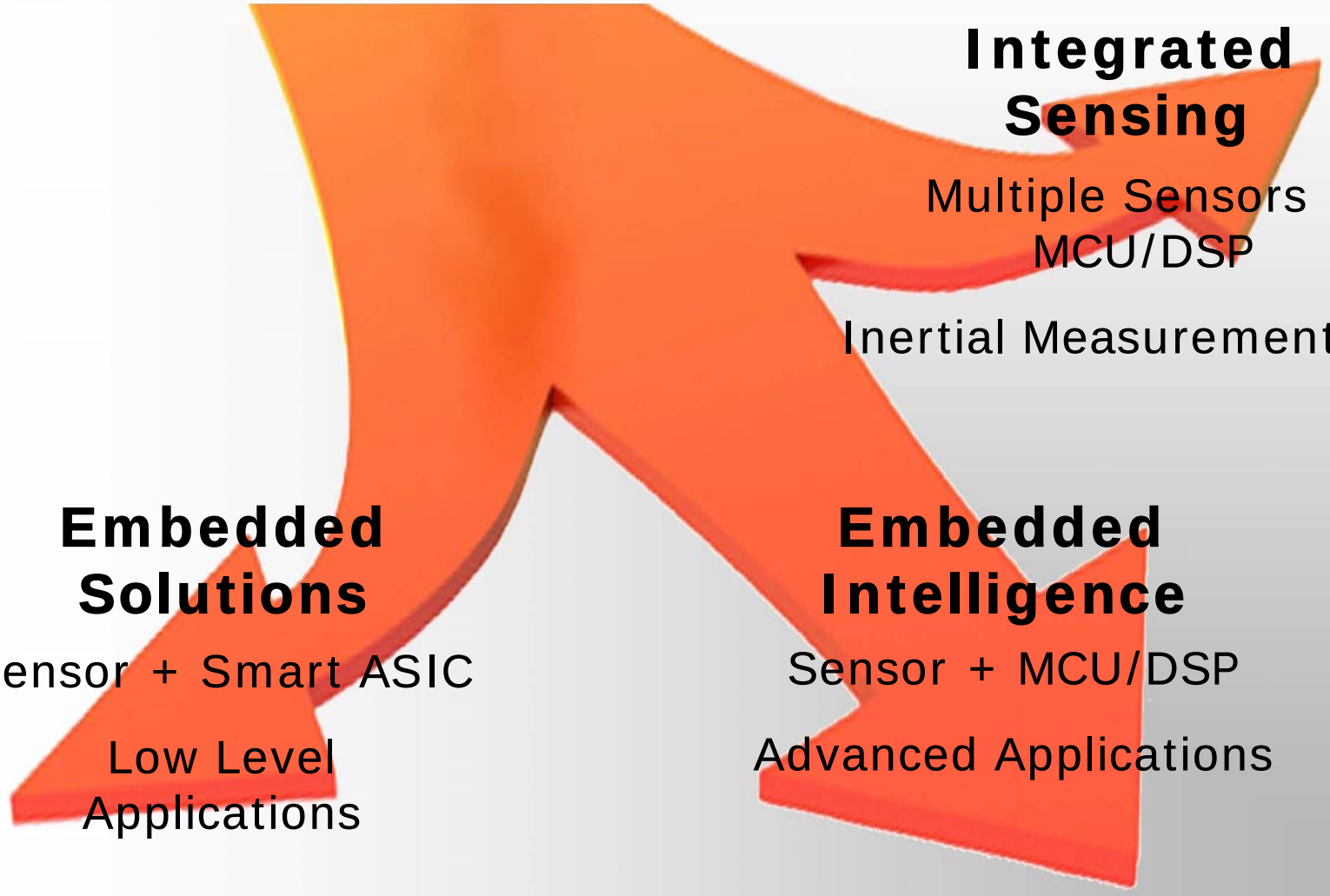
Kionix specifically focuses on inertial sensors

- Accelerometers
- Gyroscopes

Kionix serves inertial sensor markets with high volume and strong underlying demand

- Consumer electronics
- Automotive

Three Paths of Sensor Integration



Integrated Sensing

Multiple Sensors + MCU/DSP

Inertial Measurement Unit

Embedded Solutions

Sensor + Smart ASIC

Low Level Applications

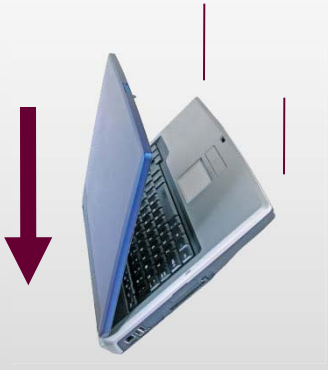
Embedded Intelligence

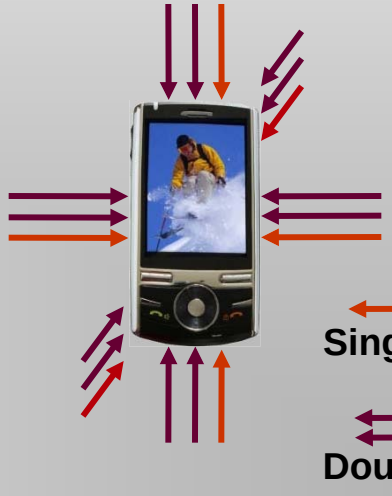
Sensor + MCU/DSP

Advanced Applications

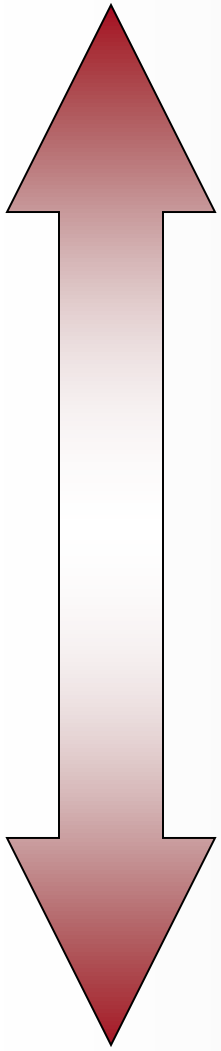
Embedded Solutions

- Embed custom engines into ASIC's
  - Freefall Detection
  - Pedometer
  - Screen Rotation
  - Directional Tap/Double-Tap™





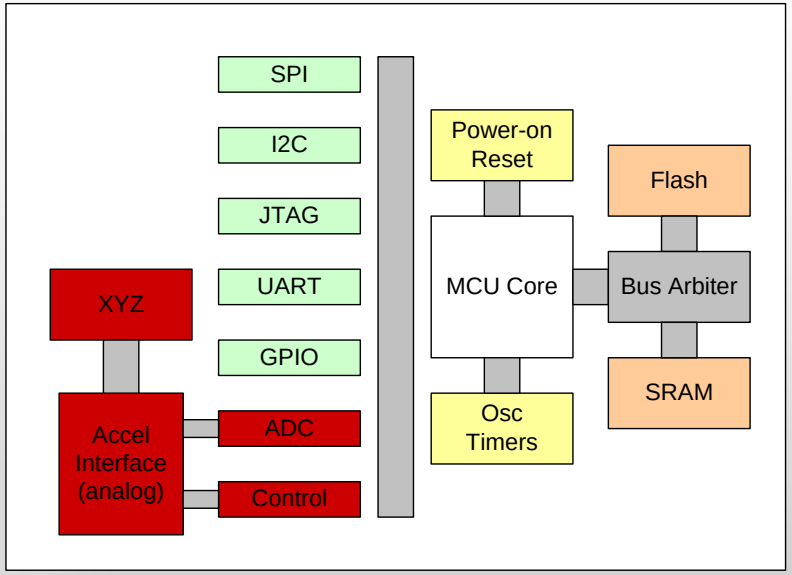
Embedded Solutions

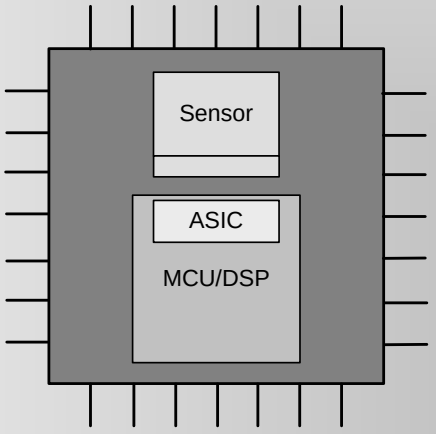


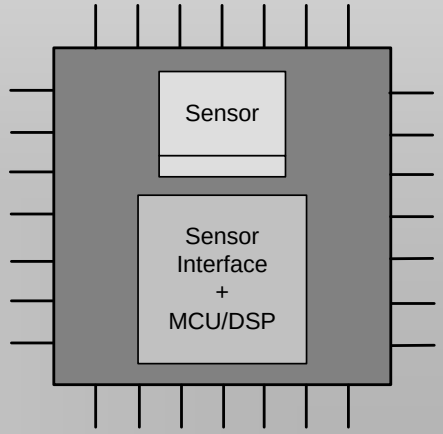
- **Advantages**
  - Simple, easy to use
    - Digital interfaces, such as I^2C or SPI, are used for user customization
    - Writing to 8-bit application registers will configure and enable the engines
    - Physical interrupt pins notify the host when an event occurs
    - Reading from the 8-bit status registers inform the results of the engines
  - Consume less current
  - Smallest size
  - Lowest cost
- **Disadvantages**
  - Computationally limited
    - Simple comparisons and bit shifting

Embedded Intelligence

- Embed MCU cores into same package
  - Pedometer (step counting, distance traveled)
  - Gesture Recognition
  - Digital Image Stabilization
  - 3D Pointer





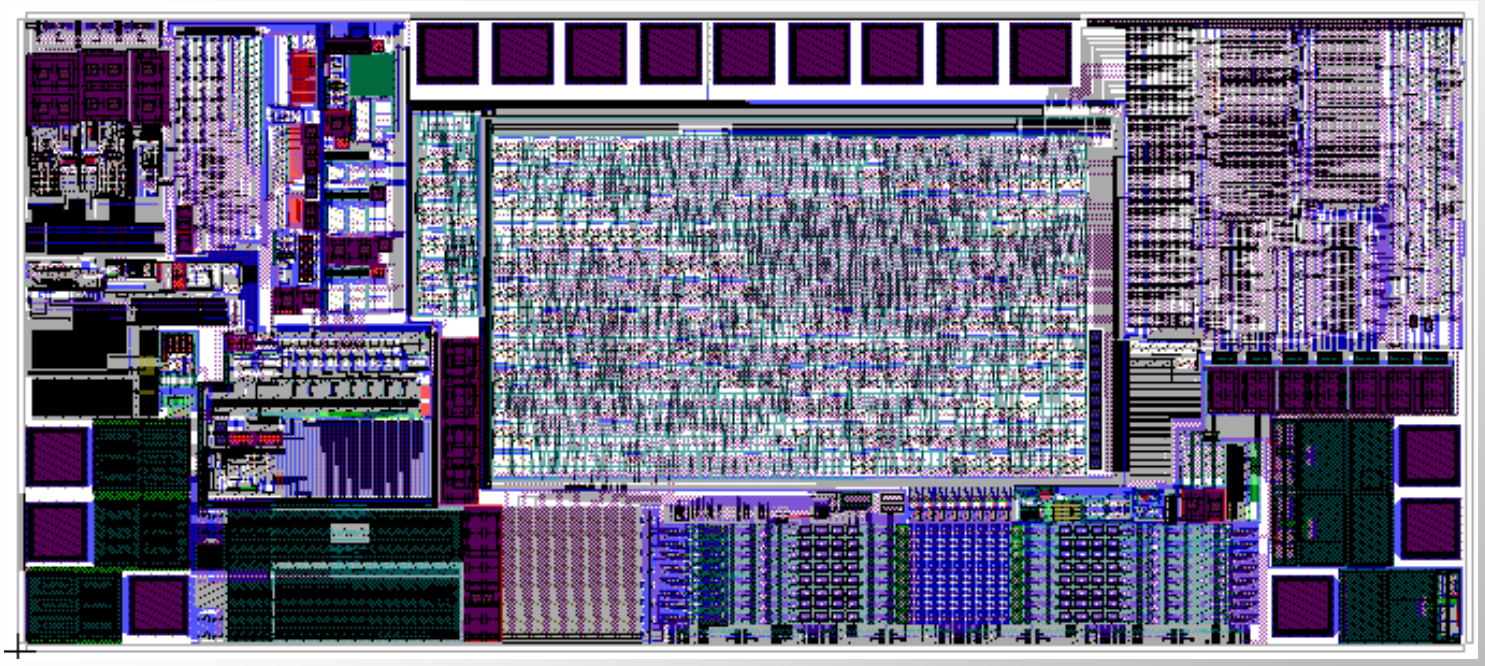


Embedded Intelligence

- **Advantages**
  - Increased intelligence
  - Opportunity to share computing resources
  - Reduced digital bus traffic in system
  - Current savings
- **Disadvantages**
  - Cost
  - Packaging challenges
  - Yield
  - Large size
  - Selecting right feature set: speed, memory, instruction set, gpio's

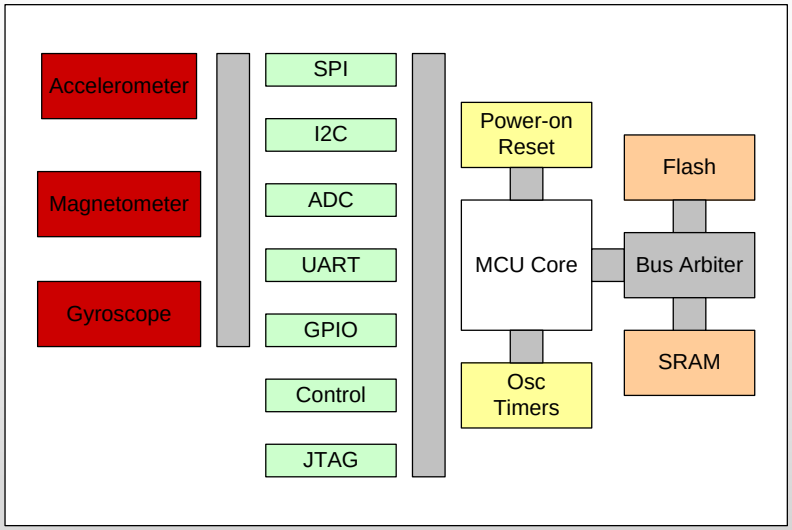
ASIC Technology Migration

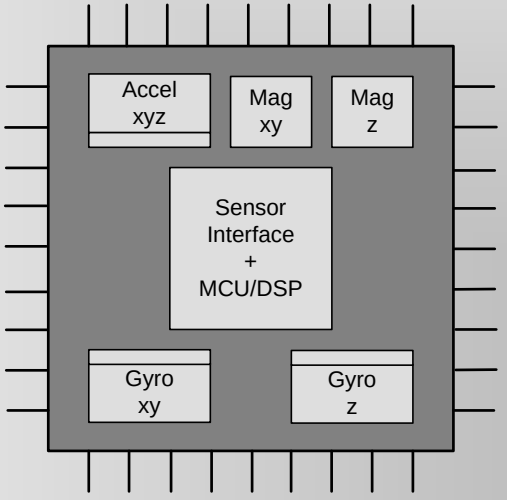
- ASIC-Sensor interface remains analog
- ASIC digital content increasing as algorithms are integrated

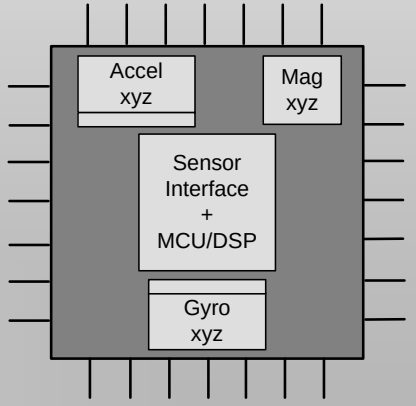


Integrated Sensing

- Combine multiple sensors into same package
  - Accelerometer + Gyro + Magnetometer
    - Inertial Measurement Unit

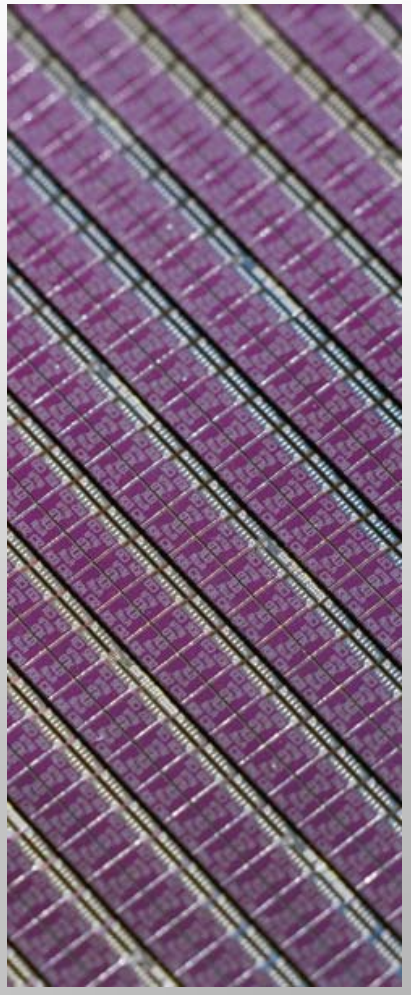






Integrated Sensing

- **Advantages**
  - Opportunity to share computing resources
  - Provide a more complex application solution
- **Disadvantages**
  - Cost
  - Yield
  - Packaging challenges
  - Loss of flexibility with mounting location

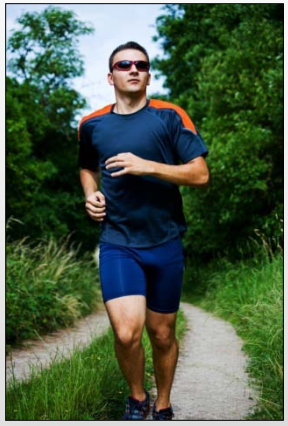


Enabling Applications

- Consumer Electronics
  - Mobile phones, Personal Media Players
    - User interface → gaming, navigation
  - Gaming
    - User interface → context awareness features
  - Digital Still Camera
    - Image stabilization → user interface
  - Computer (Netbooks, Notebooks….)
    - Hard Drive Drop Detection → security, navigation
  - Personal Navigation Devices
    - E-compass → user interface, meta-data
- Automotive
  - Electronic stability control
  - Electronic parking break
  - Headlight leveling

Expanding Markets

- Healthcare
- Fitness & activity monitoring
- Education (e-books)
- Toys
- Security/asset management
- Portable Industrial measurement/tools



Coming Age of Sensor Based Health Games

Games are using new generation of sensors

- Movement
- Haptics
- Proximity
- Global Position
- Light & Images
- Brain Waves
- Emotional States
- Physiological States

Mindflex

Health-Related Games Market

16% of the overall game business

$6.6B Worldwide

Health Games Research program

- **Goal: Advance the innovation, design and effectiveness of health games and game technologies**
- **Improve health behaviors and outcomes**
- **Physical activity games or self-care games**
- Three targeted areas of interest:

1. Theory-based design principles
2. Comparative analysis of games versus other health intervention methods
3. Meeting the needs of specific target populations

$4M in Research Grants in 2008/09

What Do Games Offer Healthcare?

For Consumers and Patients

- Engagement
  - Cognitively focus the user on the task
- Motivation
  - Provide an addictive reward structure
- Improved Compliance
  - Distract from duration of the task or pain

What Do Games Offer Healthcare?

For Healthcare Professionals

- New Provider/Patient Interaction
  - Doctor/Patient
  - Insurance Company/Member
  - Communication and Data Collection
- Better Outcomes
- Lower Costs and New Revenue Opportunities

What Do Games Offer Healthcare?

For Healthcare Professionals

- Realistic Simulations for Training
  - According to a study by the New Scientist, surgeons in training that ‘warmed-up’ using the Nintendo Wii scored 48% higher on tool control and performance (in subsequent simulated surgery) than those without the Wii warm-up’.


Wii

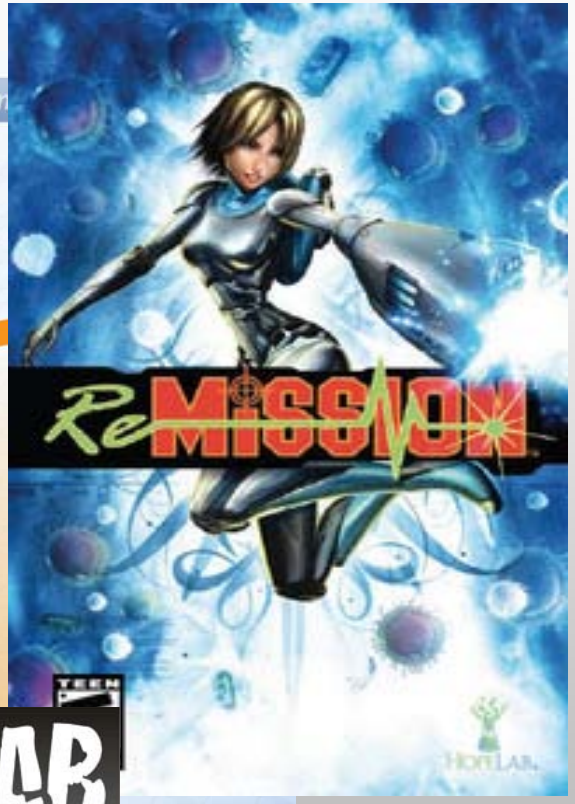
Examples of Health Related Games

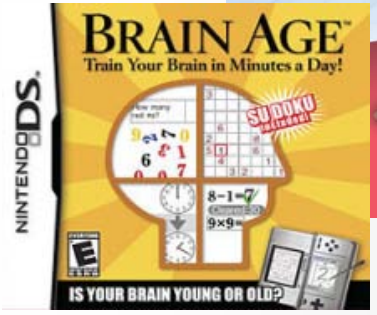
- Exergaming

  WiiFit, WiiSports and others

- Games for rehabilitation and therapy
- Games to raise awareness of health issues
- Cognitive development games
- Games to train practitioners

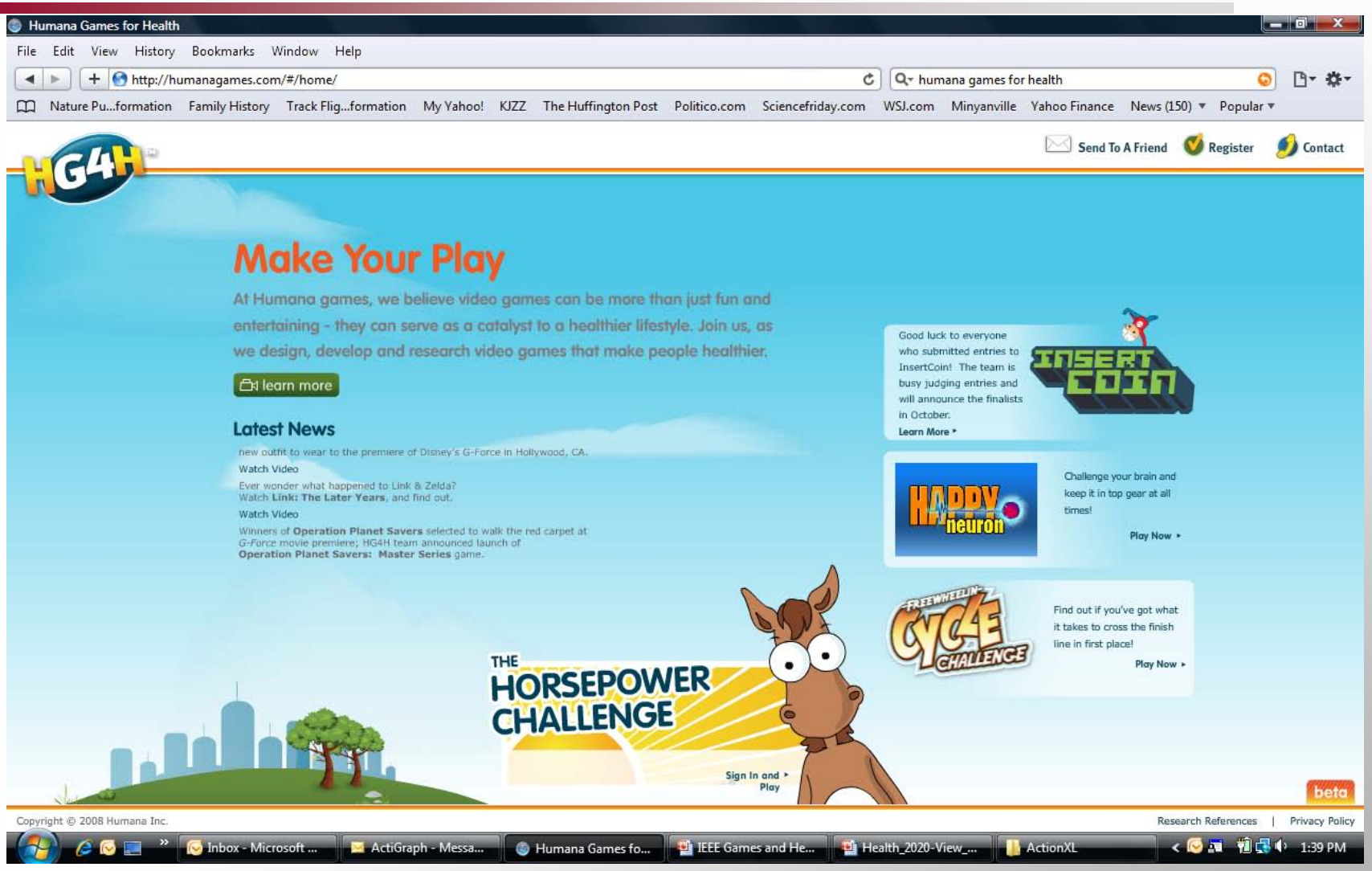
Exergaming...Condition Management... Healthy Eating & Brain Fitness





Gaming4HEALTH.com

Humana Games 4 Health



Horsepower Challenge

Teams race around the world and pass historic landmarks.

Students track their activity via their individual dashboard.

Students and teams purchase accessories using currency earned through steps.

Why Should the Engineering Community Be Interested in Health Games ?

Because They Require

New Devices and New Technologies!

Coming Age of Sensor Based Health Games

Games are using new generation of sensors

- Movement
- Haptics
- Proximity
- Global Position
- Light & Images
- Brain Waves
- Emotional States
- Physiological States

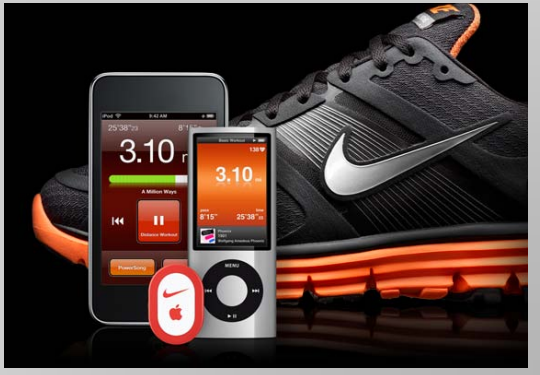
Mindflex

For Example: Activity Monitors

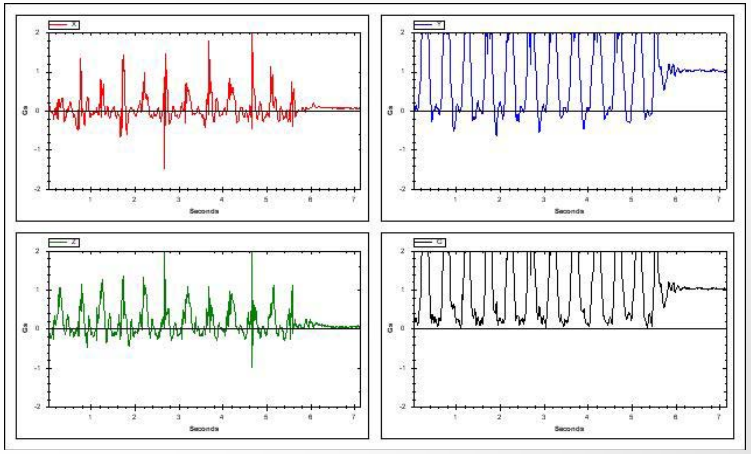
FitLinxx

BioMotion

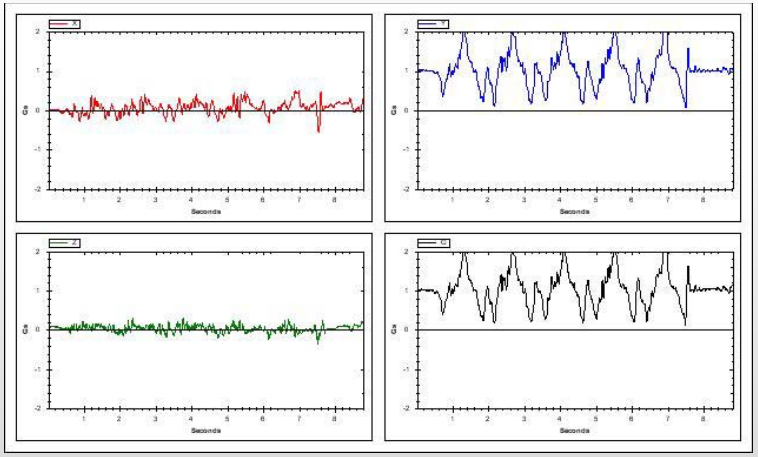
Actigraph



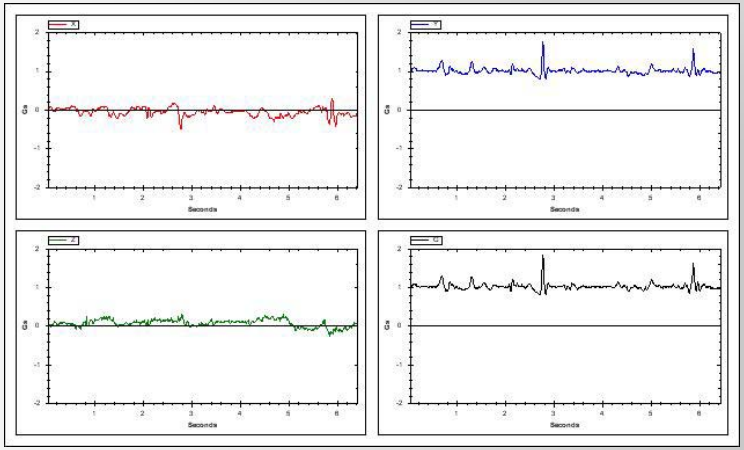
Motion Detection Algorithms



Jumping Jack



Squats



Walking

Ingestible Sensors

Proteus ingestible sensors

Proteus ingestible event markers (IEMs) are tiny, digestible sensors made from food ingredients, which are activated by stomach fluids after swallowing. Once activated, the IEM sends an ultra low-power, private, digital signal through the body to a microelectronic receiver that is either a small bandage style skin patch or a tiny device insert under the skin.

"Take two digital pills and they'll call me in the morning"

The Hand Mentor Pro™ from Kinetic Muscles

Air Muscle Actuator

An air muscle is attached to the proximal forearm.

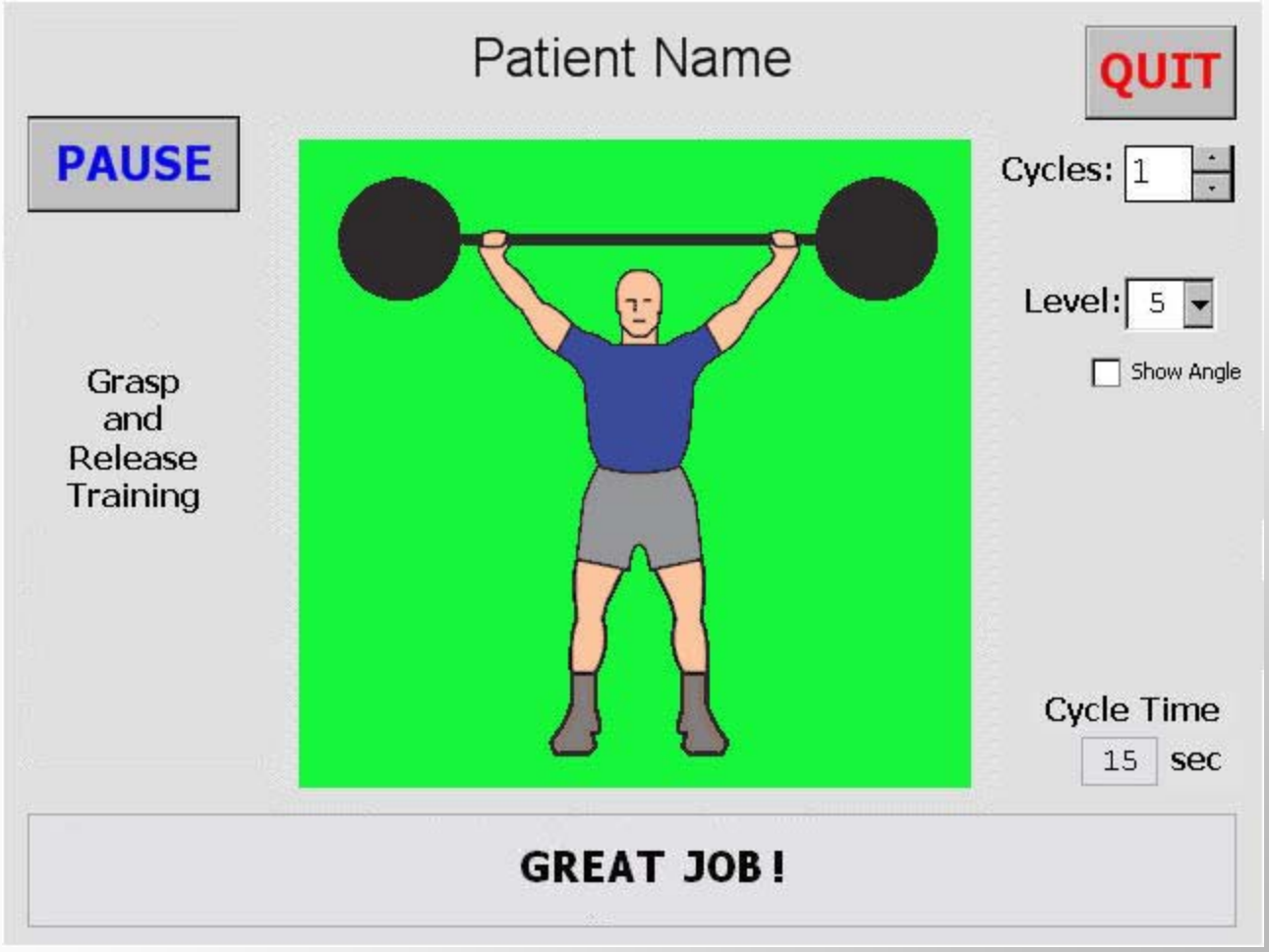
- Activation of the air muscle rotates a bar about a pivot point positioned inline with the flexion axis of the wrist.
- This action extends the wrist and fingers

Sensors

Wrist extension position is measured by an angle sensor

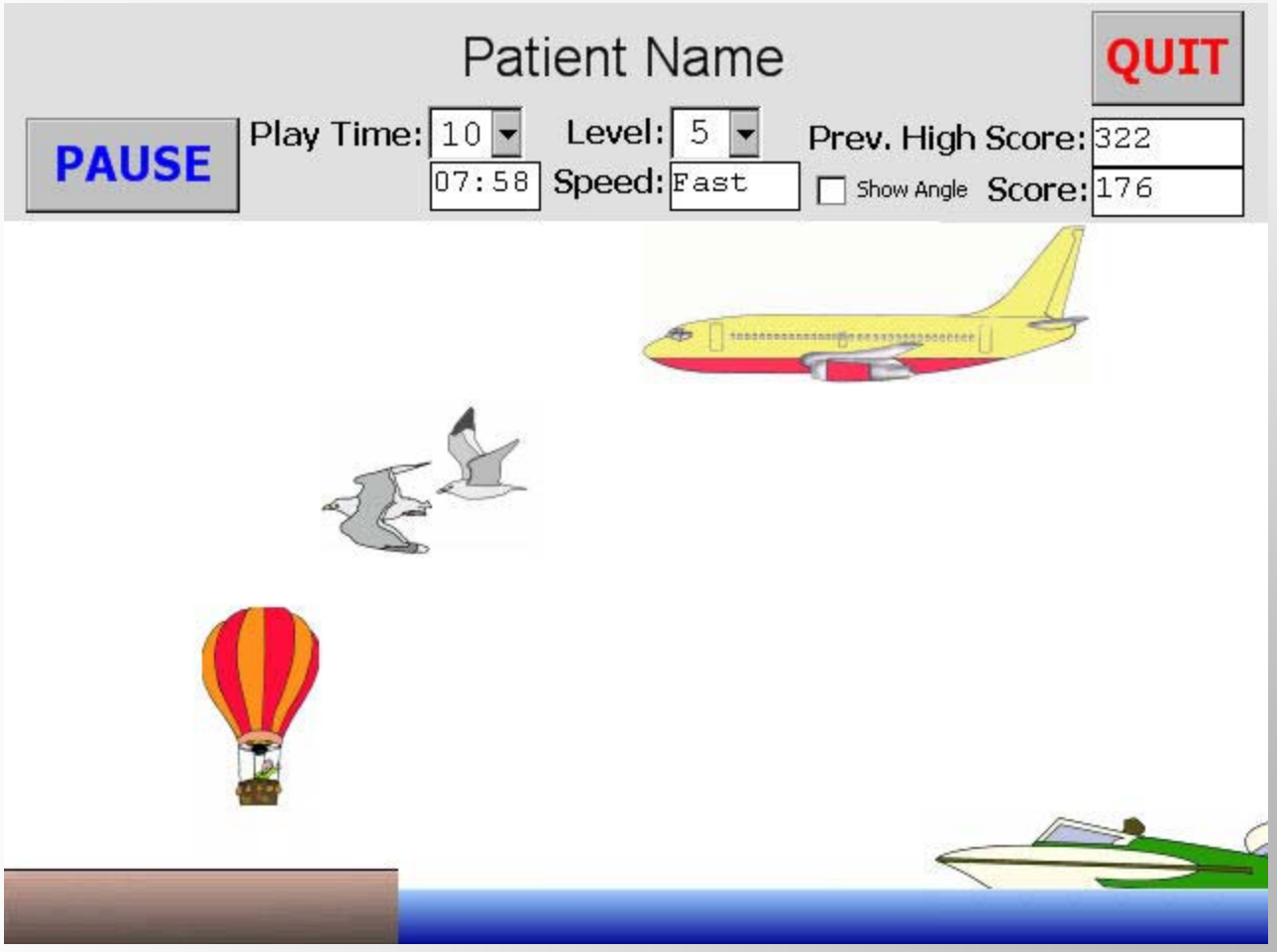
Force is calculated from air pressure and air muscle length

Basic Motor Control



The system uses game concepts to provide feedback and to monitor patient progress.

Advanced Motor Control Balloon Game



The Hand Mentor Pro™ Games

- Spasticity Reduction
  - Thermometer Gauge
- Basic Motor Control Programs
  - Motor Control Down
    - Strongman – Grasp and Release Training
  - Motor Control Up
    - Strongman – Wrist/Finger Extension Training

The Hand Mentor Pro™ Games

- Advanced Motor Control Programs
  - Balloon
    - Preset pattern of flexion and extension
    - Adds timing element to movement
  - TheraPong™
    - Random training of flexion extension position
    - Adds timing element to movement
- EMG
  - Strongman – played with muscle activity only

Gesture Designer

The Made-for-Motion Gesture Designer is a development platform that allows developers to create a gesture library that can be embedded within gaming, healthcare, or user-interface applications. Features include:

- Real-time analysis of design and test gestures
- Gesture detection in-progress for animation syncing
- Adjustable tolerance per signature
- Multiple signatures per gesture for a wider range of detection without 'sloppiness'
- Minimum of storage space for gesture information
- High-speed watch for dozens of gestures composed of hundreds of signatures
- Automatic detection of gesture beginnings and endings, no button presses required

Advanced Development Tools

Gesture Designer

- Motion application development tool
- Gesture recording
- Gesture testing and validation
- Accelerometer testing

USB Development Kit

- Test multiple accelerometers
- Sensor Scope (waveforms)
- Sensor Calc (math)
- Sensor Map (registers)
- Gesture Designer compatible