

# Thinking outside the (mobile) box: Other important high-value applications for sensor fusion

Alissa M. Fitzgerald, Ph.D. | 4 June 2013



AMFITZGERALD  
& ASSOCIATES



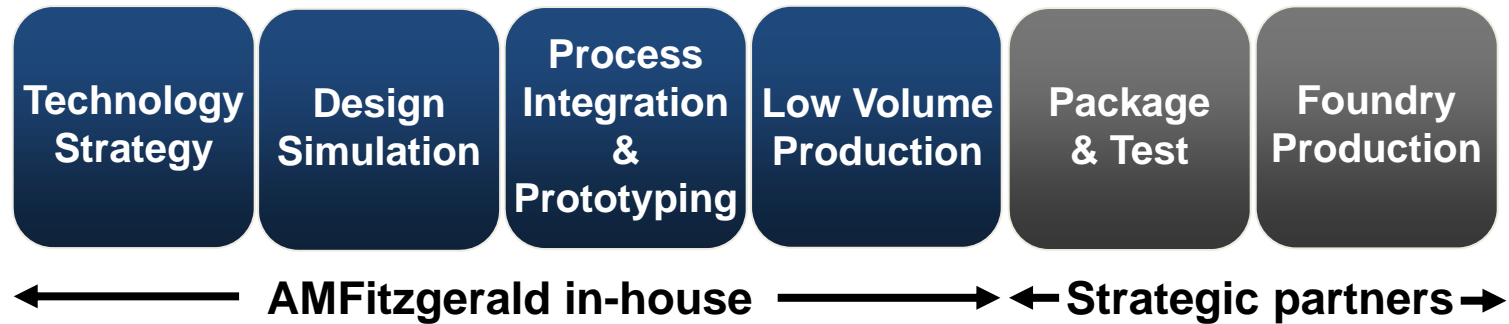
# Overview

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- **About AMFitzgerald**
- **Sensor fusion**
- **Thinking outside the mobile box**

# AMFitzgerald: MEMS product development services

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- **Design and pre-foundry development of custom MEMS**
  - In-house prototype fabrication (150 mm wafers) by our engineers, not operators
  - Process integration for volume production
  - Smooth transition to production partners
- **RocketMEMS™ semi-custom sensors**
- **Make vs. buy decisions; technology strategy**

# Sensor fusion: human brain in the [control] loop

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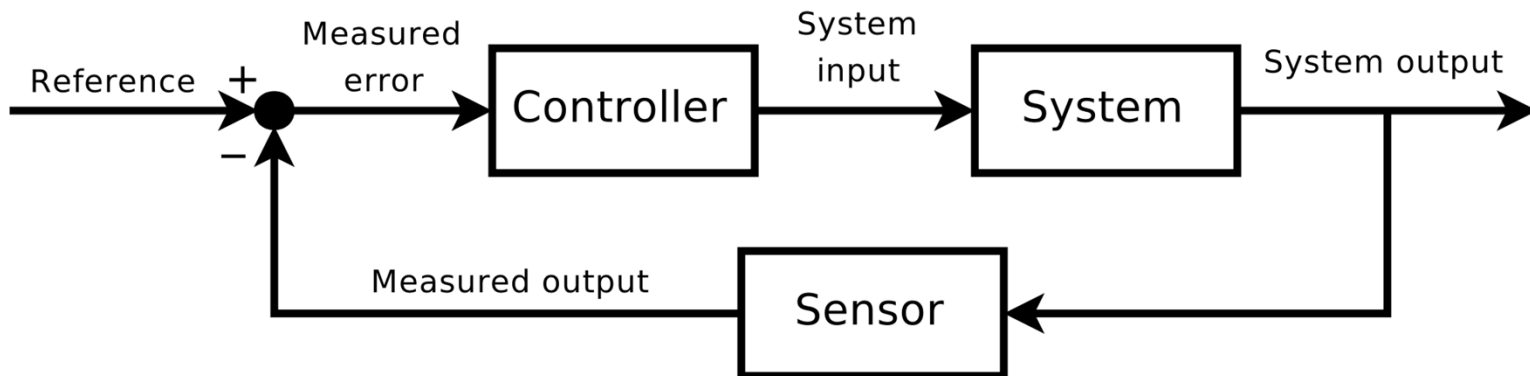


# Sensor fusion: highly trained human brain in the loop



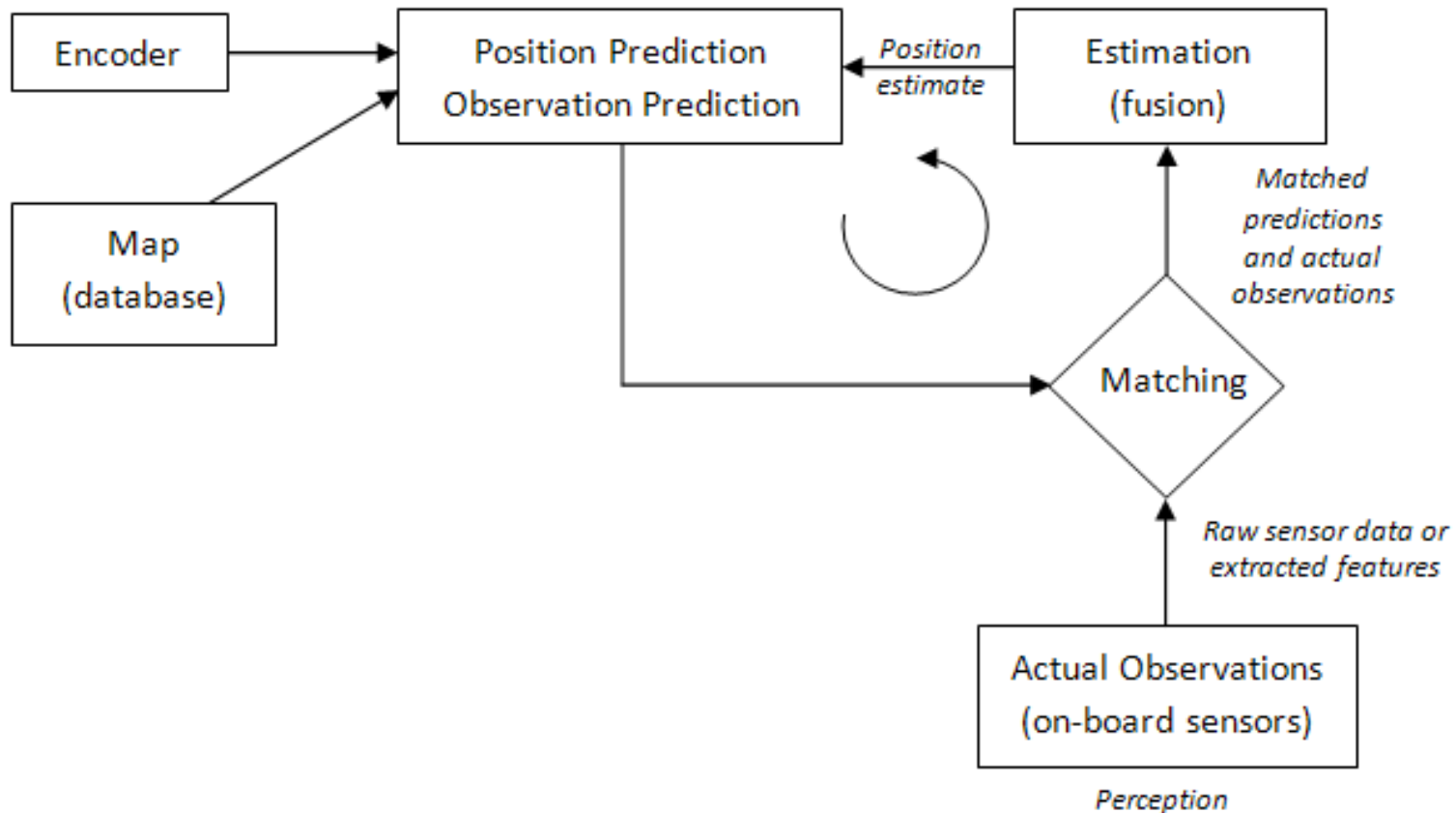
# Sensor fusion, basic: control loop

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# Sensor fusion, advanced: Kalman filters, etc.

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# Sensor fusion embodiment

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**Microprocessor**

**Sensors**

**A/D converter**

**Signal  
processing**

**Firmware**

**Algorithms**

**PCB and  
Passives**

**I/O**





## If you're not already in Mobile, you missed it

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# There are plenty of other large markets for sensor fusion

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- **Top industries in the USA (by annual revenue)**

- Petroleum
- Steel
- Motor vehicles
- Aerospace
- Telecommunications
- Chemicals
- Electronics
- Food processing
- Consumer goods
- Lumber
- Mining

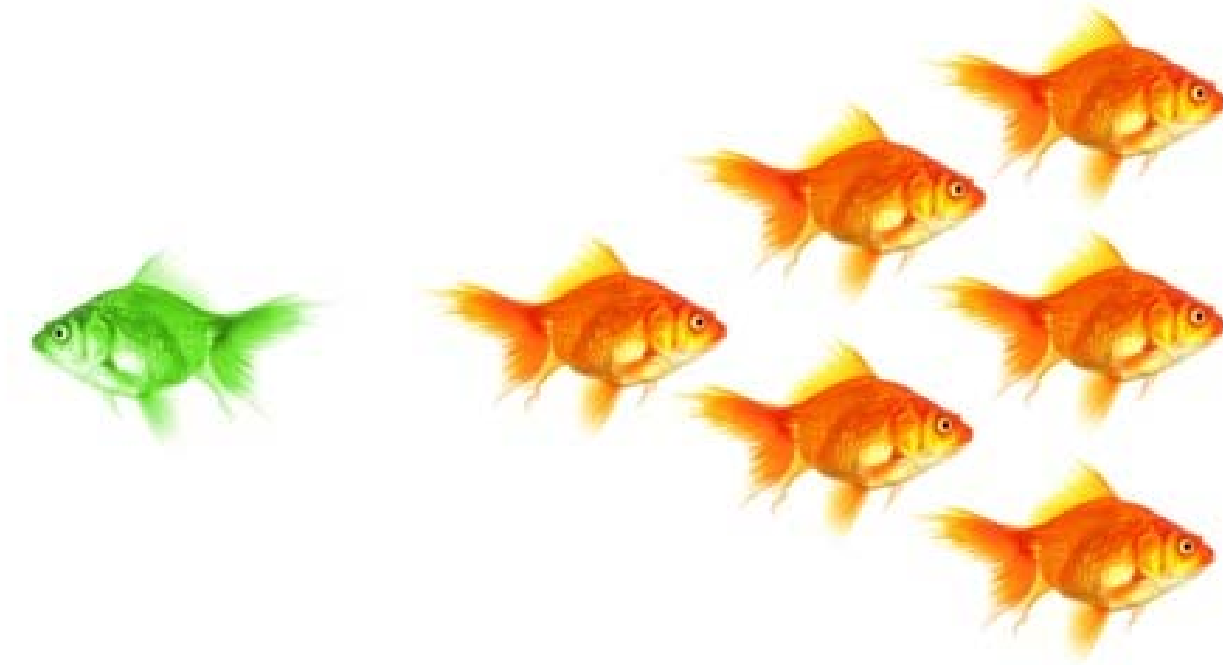
**Well-known  
to MEMS  
people**



*Source: The CIA World FactBook*

## Why not explore some of these other huge markets?

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# Heating, Ventilation and Cooling (HVAC)

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# Heating, Ventilation and Cooling (HVAC)

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**Price:**  
**\$250**

## The Nest Learning Thermostat

Keeps you comfortable.



*Data source: Wired Magazine, Oct. 2011*



## Heating, Ventilation and Cooling (HVAC)

~10M thermostats purchased each year in US (TAM ~ \$0.5-2.5B)

~250M thermostats installed in US homes, light commercial

**Price:**  
**\$250**

### The Nest Learning Thermostat

Keeps you comfortable.



*Data source: Wired Magazine, Oct. 2011*

# Intelligent Home Appliances

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**Vacuum**



***Roomba***

**Pool cleaner**



***Mirra***

**Gutter cleaner**



***Looj***

*Source: iRobot*

# Intelligent Home Appliances

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**Vacuum**



**Roomba**

**MEMS inertial  
sensors**

**Pool cleaner**



**Mirra**

**IR sensors**  
**Touch  
sensors**

**Gutter cleaner**



**Looj**

**Machine  
learning**  
**Acoustic  
sensors**

*Source: iRobot*

# Intelligent Home Appliances

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***LG TrueSteam  
Dryers***



***Breville Smart Oven***

# Intelligent Home Appliances

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**Humidity  
sensors**



***LG TrueSteam  
Dryers***

**Temperature  
sensors**

**Optical  
sensors**



***Breville Smart Oven***



# Animal Management

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## Bovine estrus cycle detection, with iPhone app



*Source: Dairymaster*

# Animal Management

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## Bovine estrus cycle detection, with iPhone app

**Price: \$150**



**MEMS motion  
sensor**

**Temperature  
sensor**

*Source: Dairymaster*

# Animal Management

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~265M dairy cows in the world (TAM ~ \$40B)

Price: \$150



**MEMS motion  
sensor**

**Temperature  
sensor**

Source: <http://www.dairyco.org.uk/>

# Precision Viticulture

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- **Optimize growing conditions and improve vineyard yield using technology**
  - Promoted by CSIRO in Australia
- **Measurement systems:**
  - GPS mapping
  - GIS (geology, terrain)
  - Meteorology
  - Soil sensors
  - Light sensors



*Sources: CSIRO, Wine Institute*

# Precision Viticulture

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- **4 billion sq. meters of vineyards in USA**
  - \$3.5B in grape sales in 2007
- **Distributed sensor network opportunity**
  - Assume one sensor cluster per 100 sq. meters (conservative)
    - 40M clusters just for USA
  - Assume \$100/cluster
  - USA TAM ~ \$4B
  - World TAM ~ \$40B?



*Sources: CSIRO, Wine Institute*



# Gardening

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## Parrot Flower Power



**Similar product: Koubachi (Swiss)**

# Gardening

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## Parrot Flower Power



**Similar product: Koubachi (Swiss)**



**Light  
sensor**

**Temperature  
sensor**

**Humidity  
sensor**

**Soil fertility  
(salts) sensor**

# Infinite combinations for sensor fusion

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## Navigation

- Accel
- Gyro
- Magnetometer
- Altimeter
- Ultrasound

## Environment

- Pressure
- Temperature
- Humidity
- Light
- Sound
- Occupancy

## Biological

- Gas
- Particles
- Organics
- Salts
- DNA
- Bacteria, etc.

# The iPhone has trained us to expect sensing devices

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**Sensor fusion is  
already part of  
this 1 yr. old  
child's world**

## Sensor fusion will drive demand for more sensors

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- **Will the MEMS industry finally start to streamline?**
  - Standards: first steps taken
  - Reference designs
  - Faster time to market
  - Help end users integrate sensors more easily
- **The “Internet of Things”**



# RocketMEMS™: a new era in MEMS development

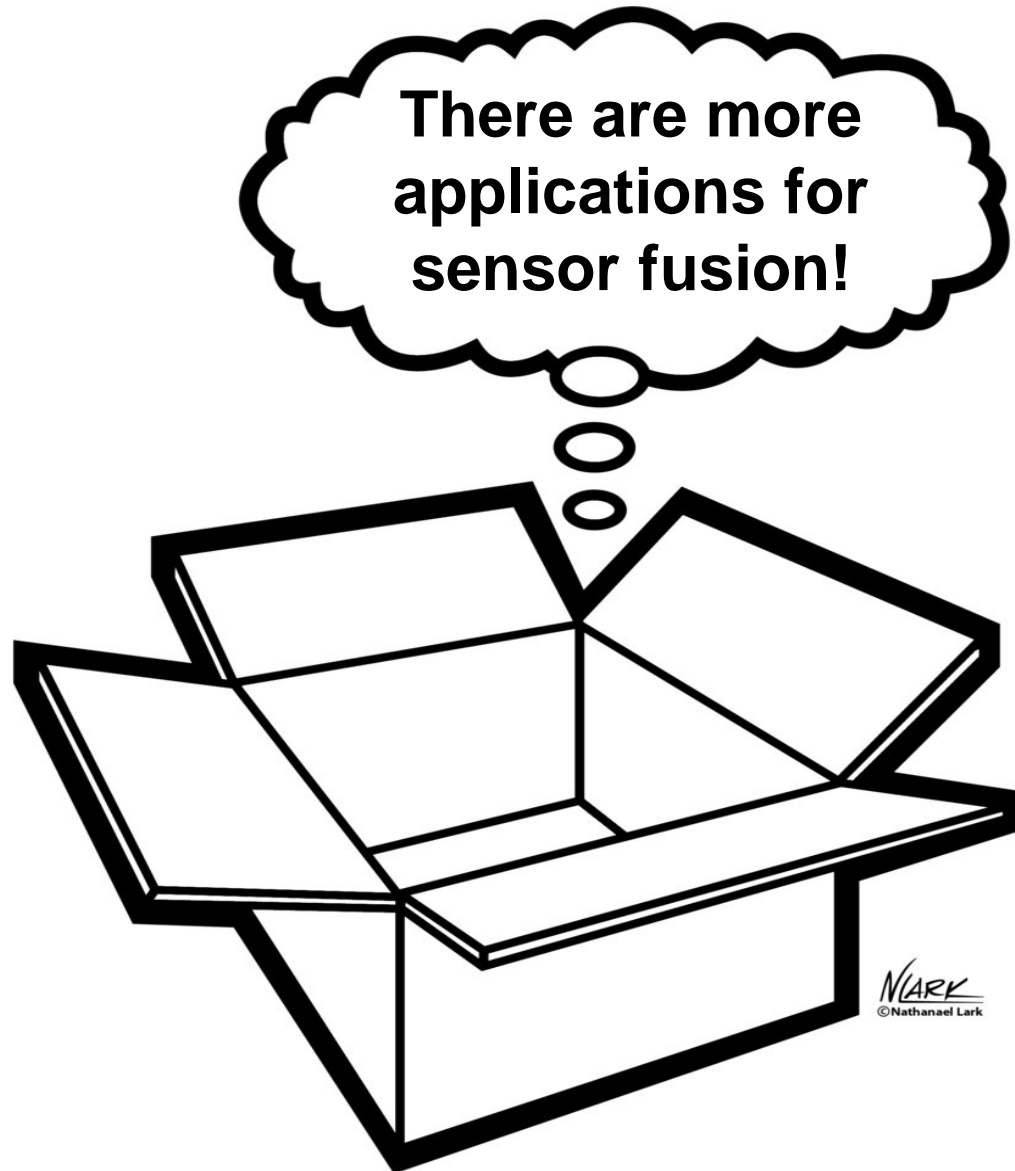
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- Foundry-ready sensor designs
  - Lowers risk, time and cost of new sensor development
  - Supports emerging markets, lower initial volumes
- First run: pressure sensors, Q3 2013, at Silex Microsystems
- Customer supplies sensor spec, AMFitzgerald delivers customized chips run on established foundry process
- More sensors in the future...

# Summary

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## Company contact information

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