Challenges in Developing Intelligent Geosystems
(and the pros/cons of interdisciplinary research)

Tracy Camp

SmartGeo
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## Road Map

- SmartGeo Applications, Goals, and Challenges
- Custom Hardware
- Trends in WSN Research
- Lessons Learned
- Pros and Cons of Interdisciplinary Research

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An interdisciplinary graduate program
in the area of Intelligent Geosystems

NSF

Intelligent Geosystems

natural or engineered
earth systems enabled to
sense their condition and
adapt to meet their objective

# Intelligent Earth Dams/Levees

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# Current State of Practice: Periodic Wired Geophysical Monitoring

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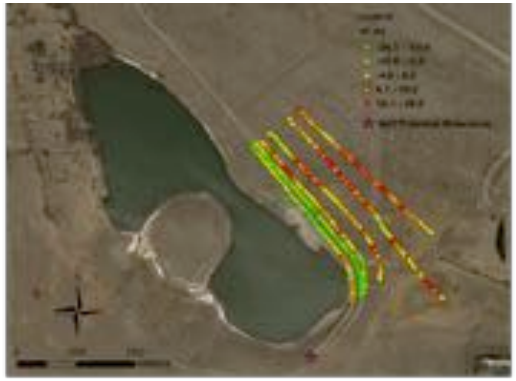
# Goal: 'continuous' monitoring using a (geophysical) WSN

earth systems/ structures enabled to sense their environment and adapt to meet their objective

Long Lake Dam, Golden, CO



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# CS/EE Technical Challenges

- unable to integrate geophysical measurement techniques into off-the-shelf mote platforms
- collection of data in a resource constrained environment = use compressive sampling?
- geophysical measurement techniques require localization accuracy at the cm level
- geophysical measurement techniques require time synchronization at the micro-second level
- processing of data (ML and HPC)

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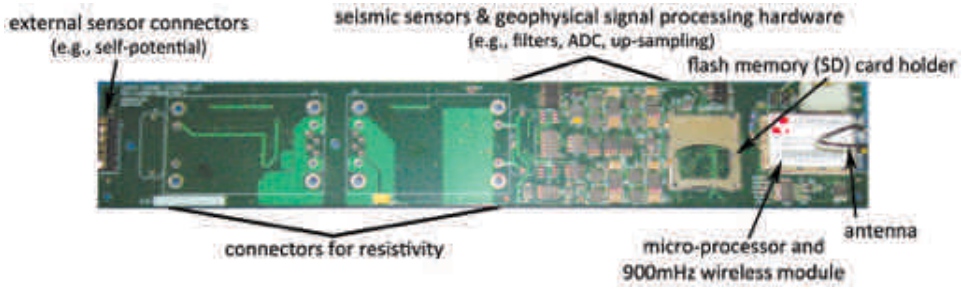
# gsMote: geophysical sensing Mote

- geophysical sensors: self potential, seismic, infrasound, resistivity
- High/Low pass hardware filters
- Amplifier
- AVR XMEGA256A microprocessor
- 24-bit off chip ADC
- 64kB FeRAM
- 2-32GB persistent flash storage
- 802.15.4 Radio (900 mHz with 2km range)



# gsMote PCB

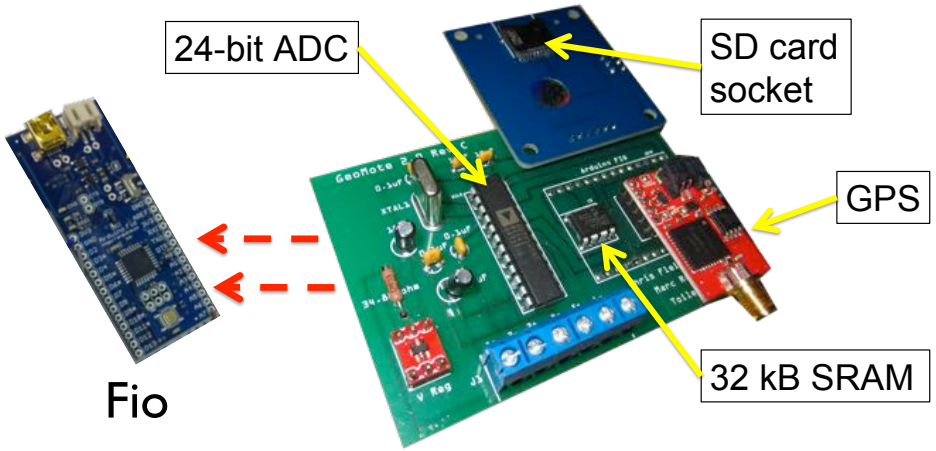


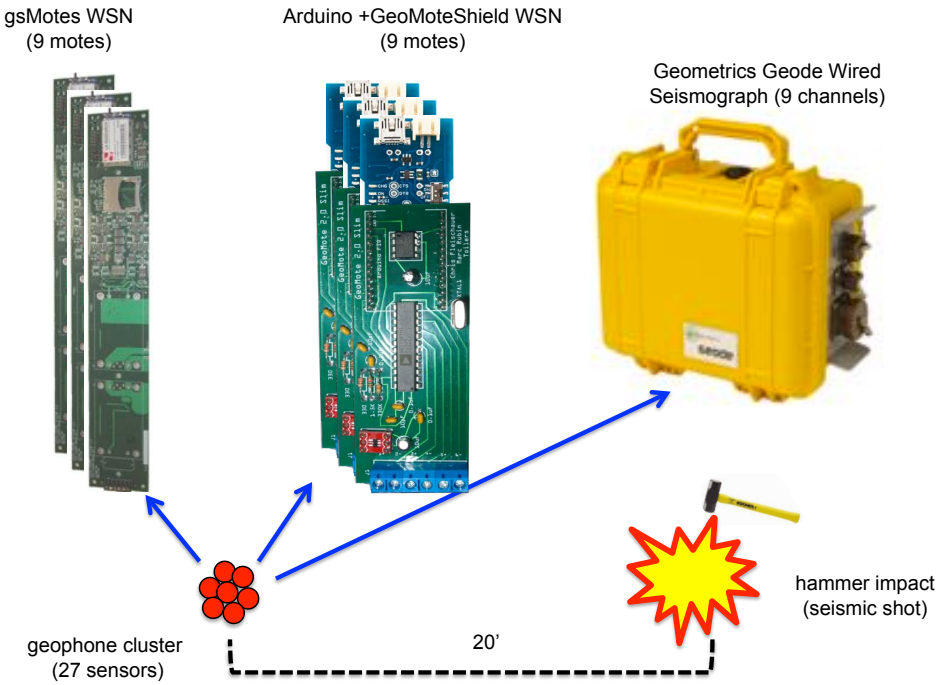


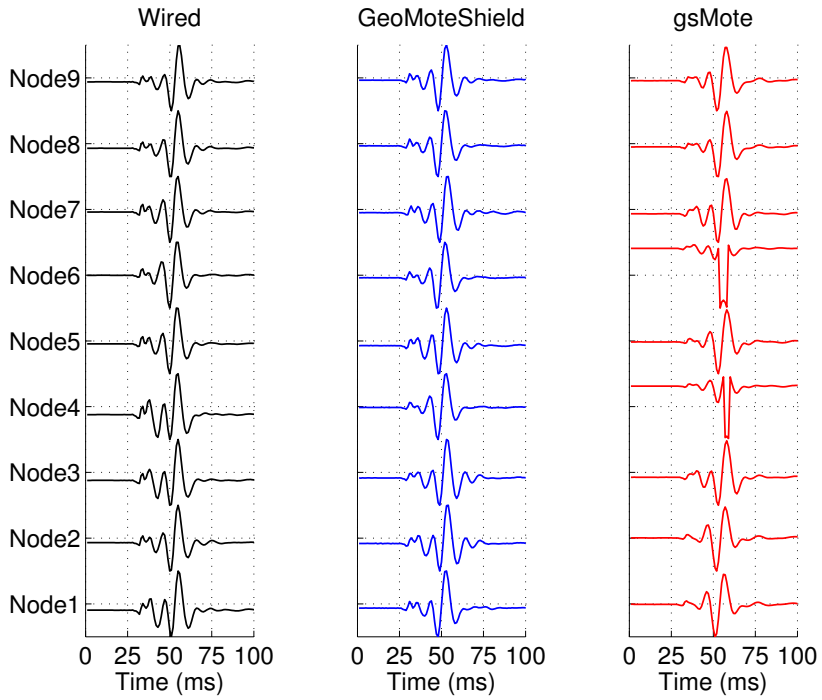

# GeoMoteShield

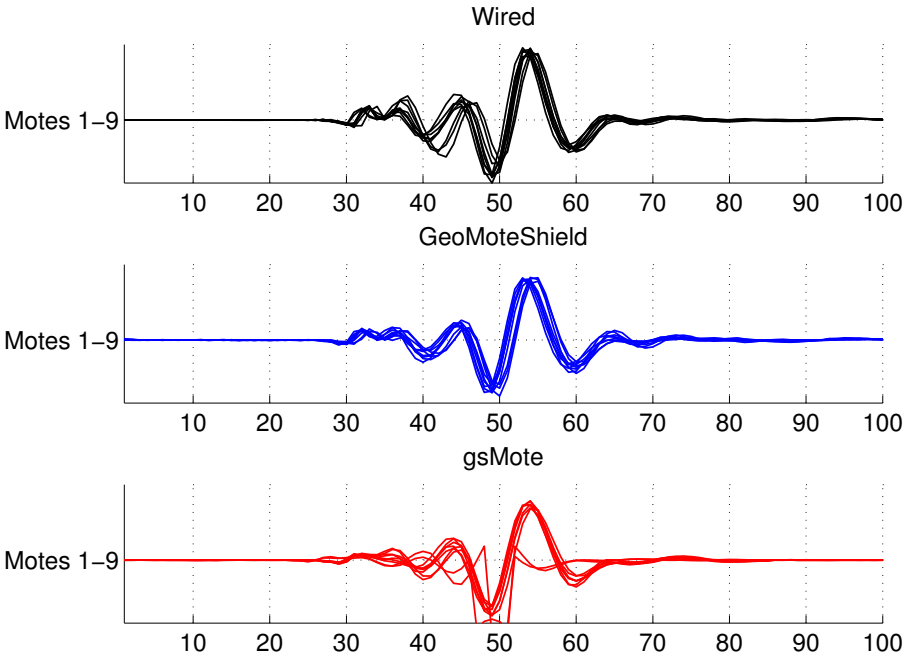
- geophysical sensors: self potential, seismic, infrasound, resistivity
- Amplifier
- 24-bit off chip ADC
- 32kB RAM
- 32GB persistent flash storage
- GPS

# GeoMoteShield with Arduino Fio



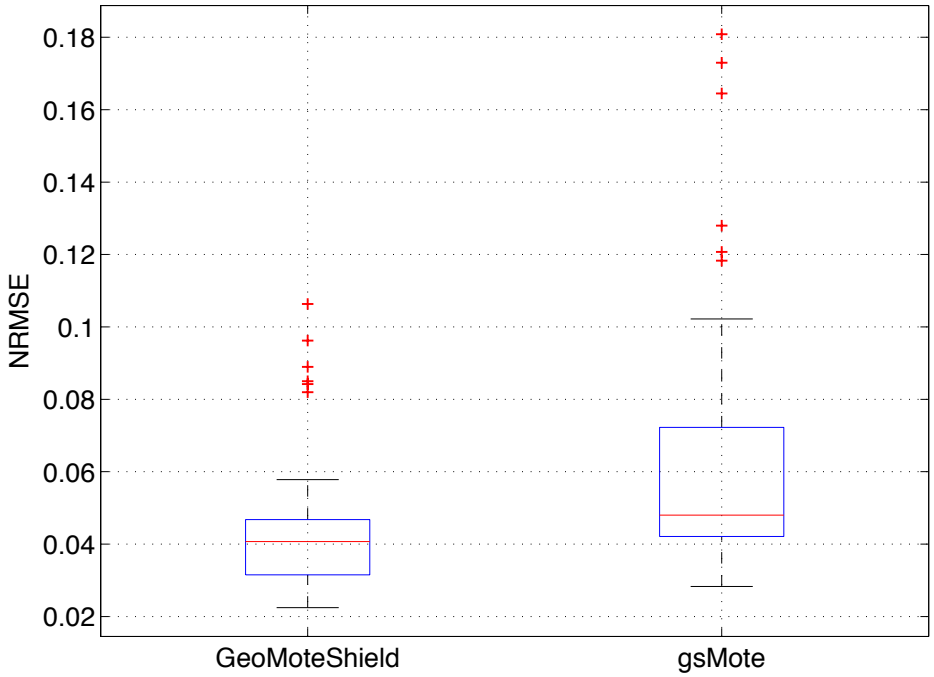



# Error Results

$$NRMSE = \frac{\sqrt{mean((x_{ij} - y_{ij})^2)}}{max(x_{ij}) - min(x_{ij})}$$

*x*: wired system
*y*: wireless system
for node *i*, event *j*

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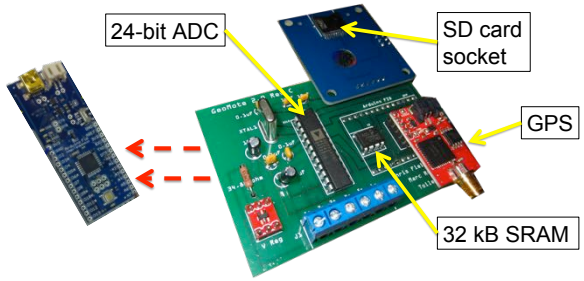
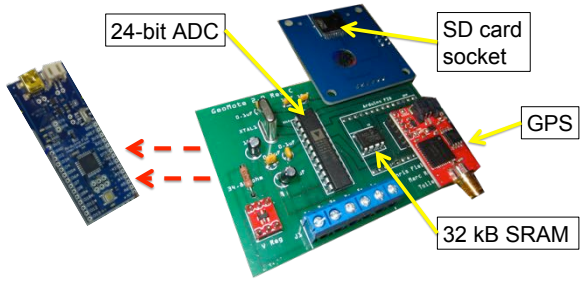


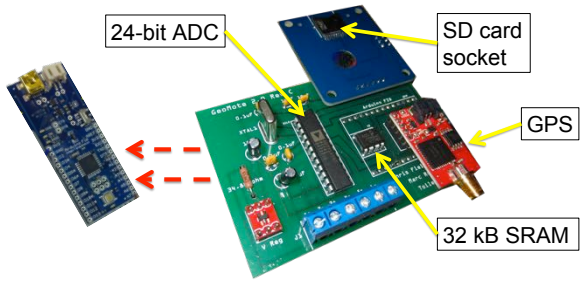

Arduinos are programmed in object-oriented C++ (no need to learn nesC).





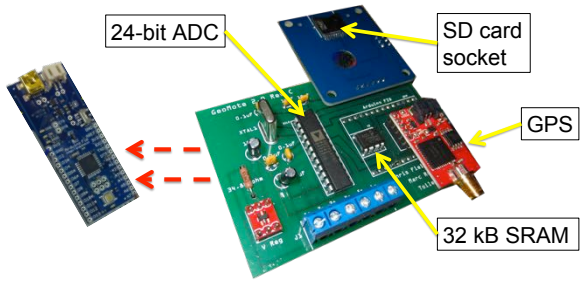

Arduino Fio code is 100% open source and well documented (unlike gsMote and TinyOS).



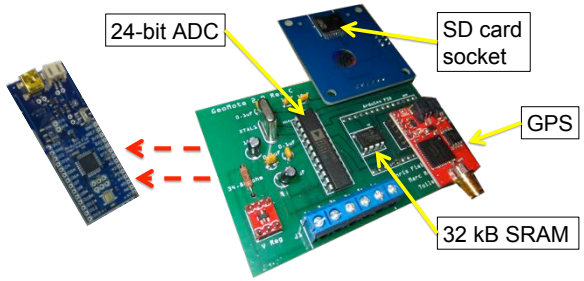



Arduinos have a huge online support community.



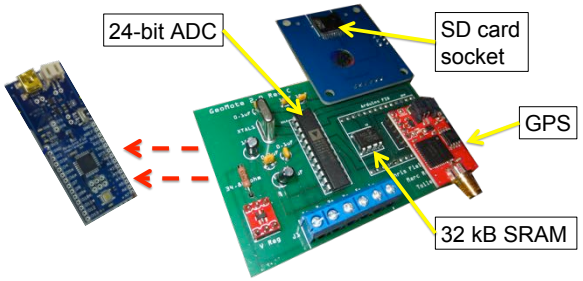



Arduinos can be easily integrated with many different types of sensors / devices (GPS, ADC, SD card, RTC, LEDs, etc.)



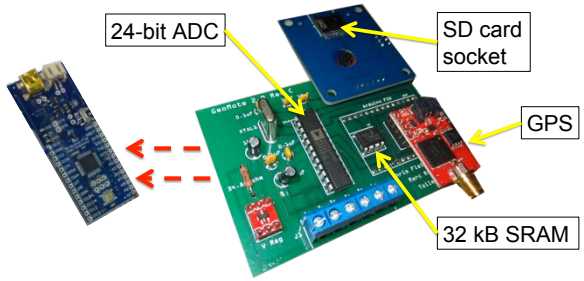

Arduinos can easily support different types of XBee radios (802.15.4, 802.11, 2.4 GHz, 900 MHz, low range, long range).






Arduinos do not have an operating system (unlike TelosB and TinyOS).





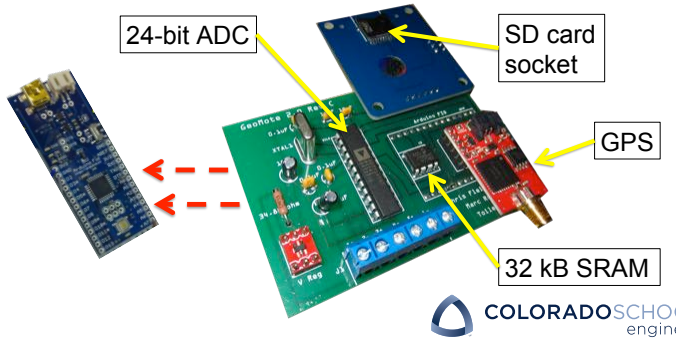

Arduinos are NOT low power.



# Main Take Away

Arduino:

future of applied WSN research?



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## Inter-disciplinary Research: Pros

- many tough, relevant, real-world research problems exist
- significant funding available for inter-disciplinary research



## Inter-disciplinary Research: Cons

- learning the tough, relevant, real-world research problems takes time
- finding the right publishing venue can be difficult
- getting grants can be hard
- communication issues exist



## My Students Rule

Recently graduated students: Doug Hakkarinen, Brian Hoenes, Aarti Munjal, Marc Rubin, and Kerri Stone

Current Ph.D. Students: Wendy Belcher, James Maher, Thyago Mota, and Henri van den Bulk

Current M.S./Undergraduate Students:

Santiago Gonzalez, Kolten Robison, Brandon Rodriguez, and ...