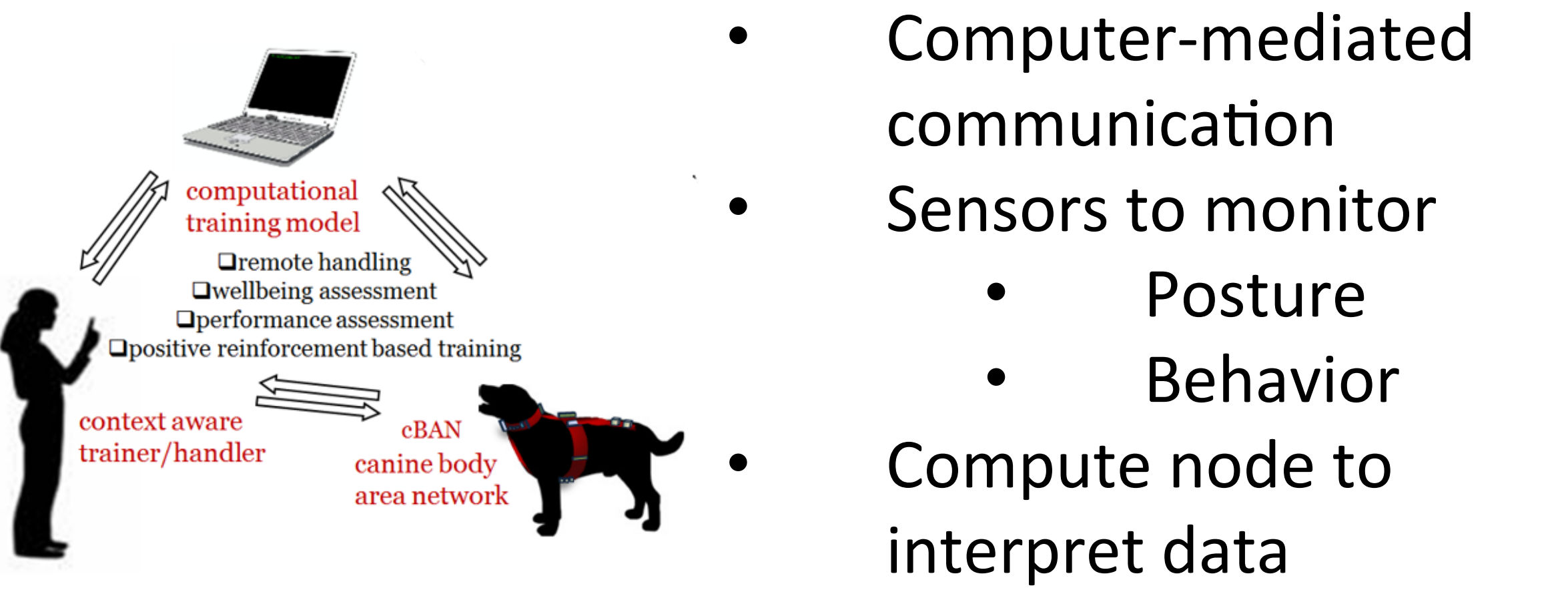
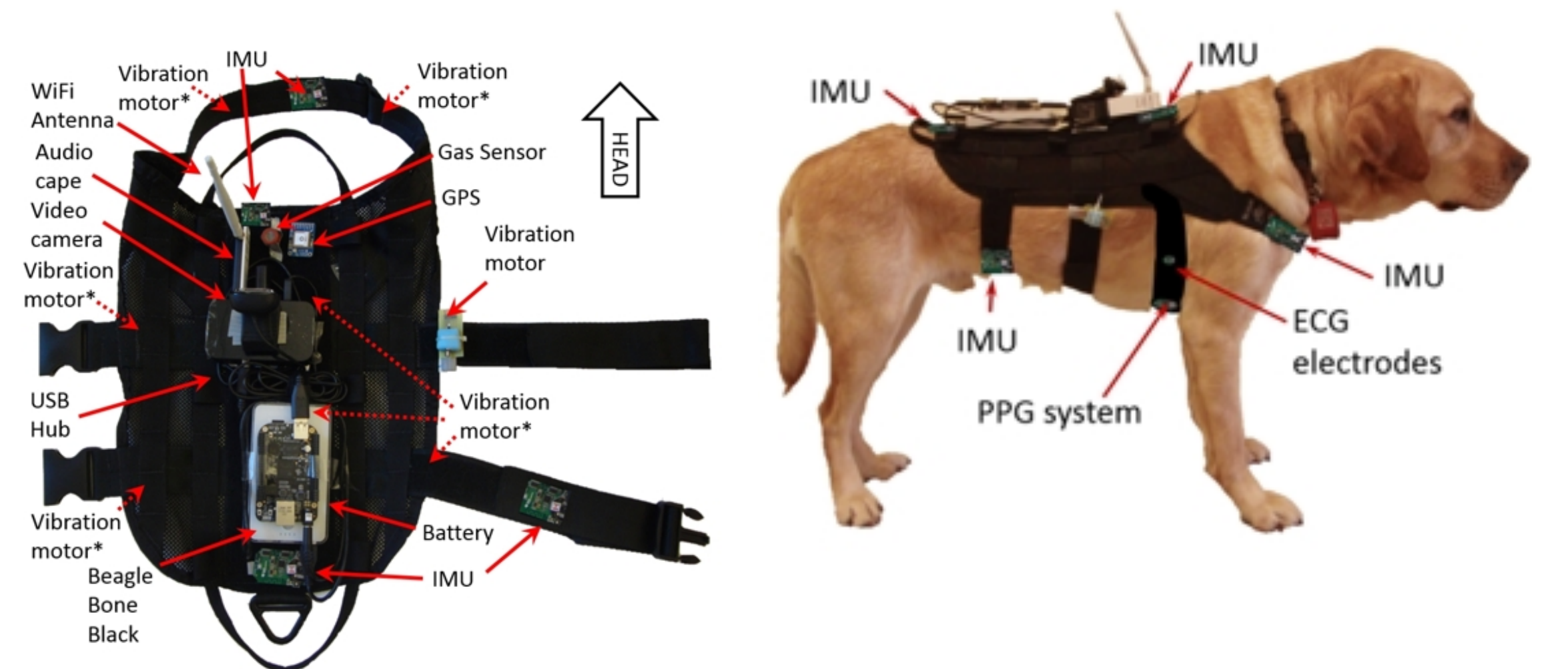


## Vision:



## Platform:



### Smart Harness

- Beaglebone Black (BBB)
- 802.11 for communication
- Between 2 and 4 IMUs for posture data
  - 3-axis accelerometer
  - 3-axis gyroscope
- Streaming video
- Speaker to play transmitted or pre-recorded messages
- DC vibrating motors to provide haptic cues integrated in 8 locations
- Battery to power vibration motors and BBB

### Physiology Strap

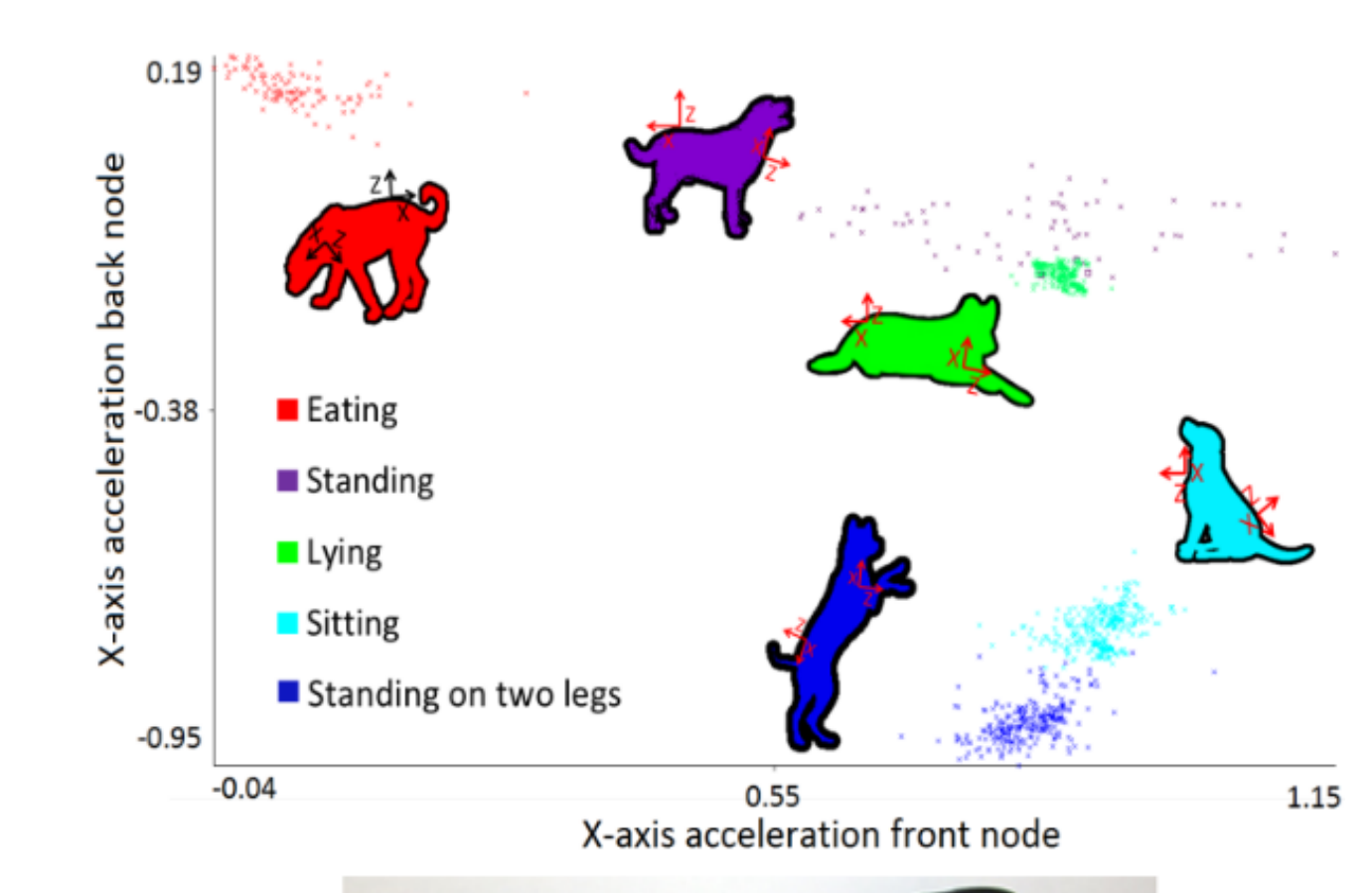
- Wearable physiological monitoring, capable of integration into smart harness
- No need to shave dog for tissue contact
- Photoplethysmogram (PPG) system measures light absorption in the skin to estimate oxygenation
- Electrocardiography (ECG) records heart variability

## Year 1 Accomplishments:

In the first year of this project, we have made notable advances in three key areas:  
 1) Posture recognition with Inertial Measurement Units (IMUs); 2) Designing and packaging a wearable physiological monitoring strap; and 3) Computer-assisted training via posture recognition and remote reinforcement.

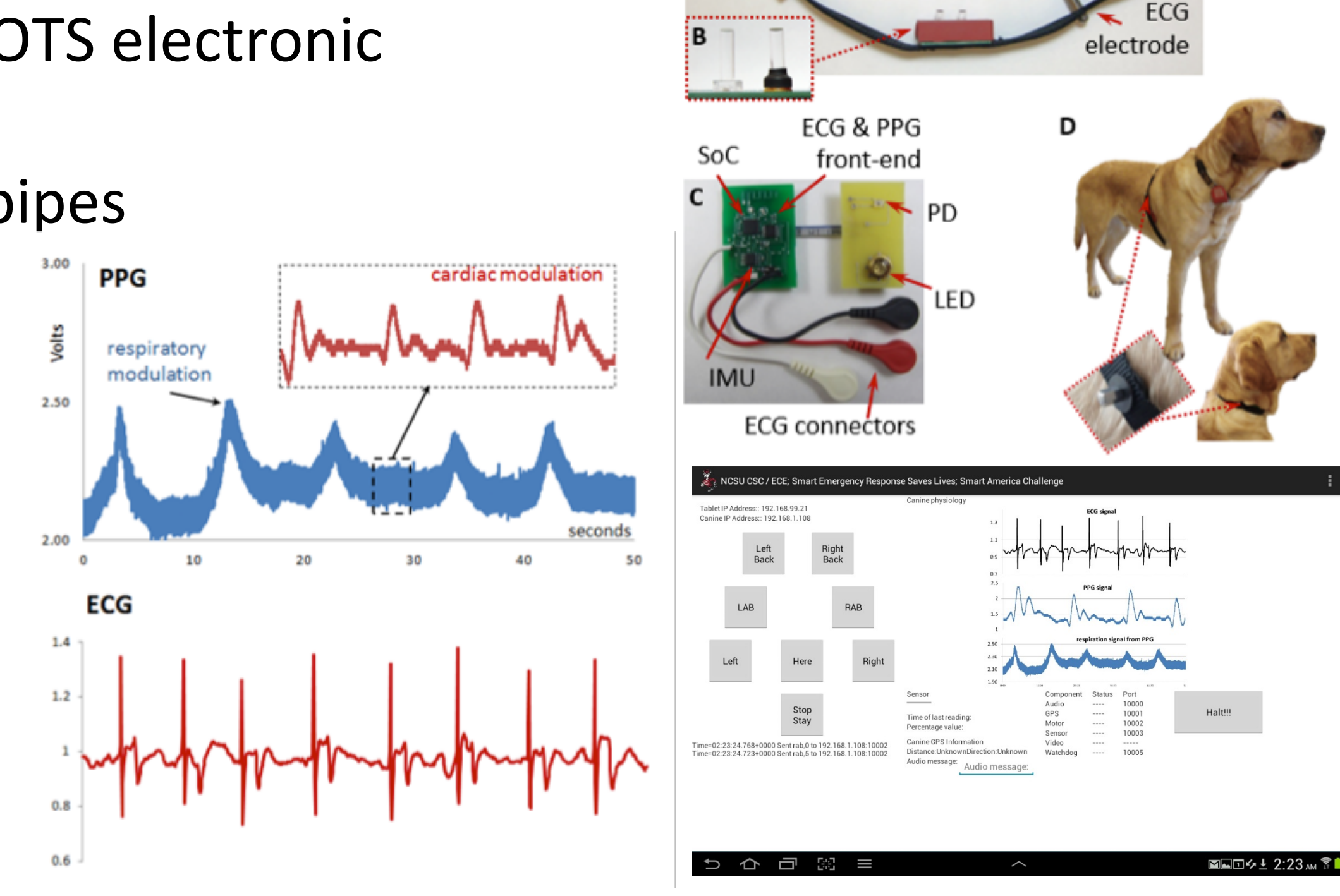
### 1) Posture recognition:

- Two IMUs on smart harness, one on chest and one on back
- Sampled at 10Hz
- Real-time labels applied using keyboard
- Accuracy 99+% on average



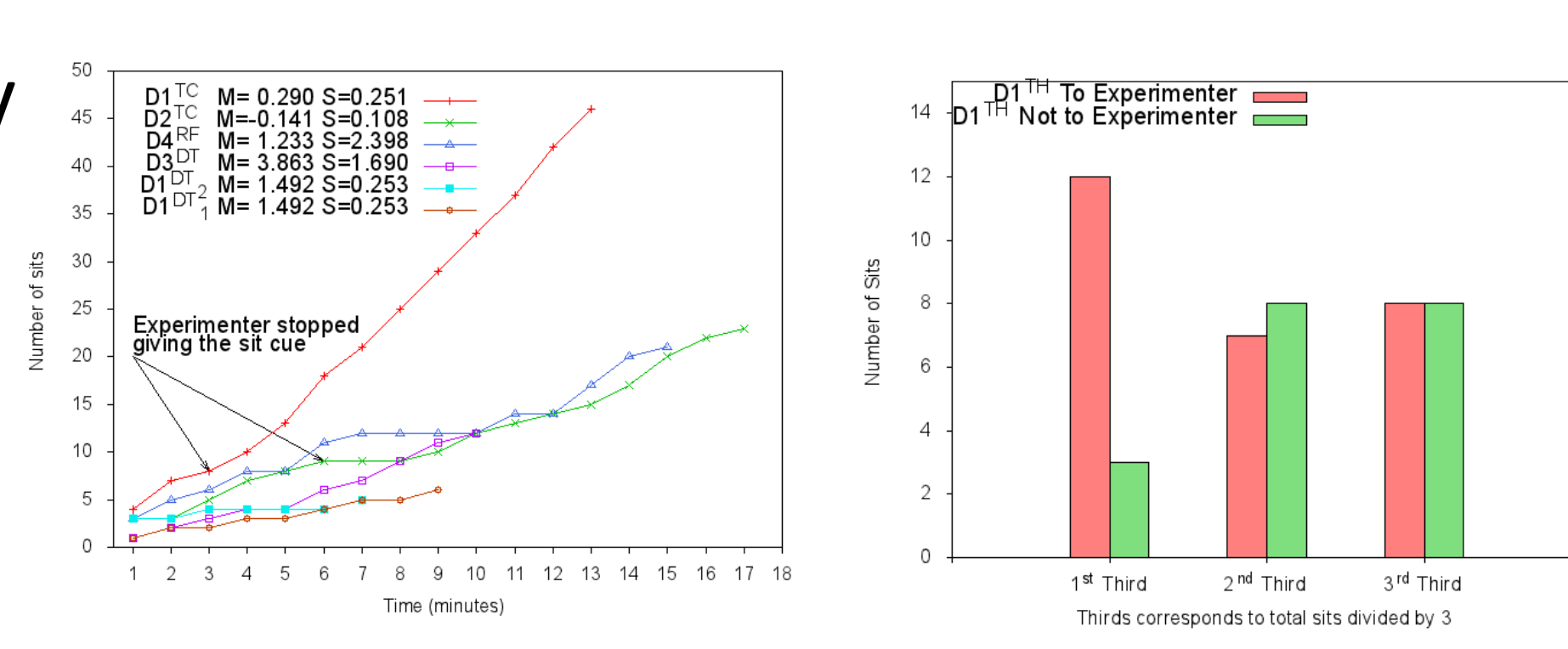
### 2) Physiology strap:

- ECG electrodes using COTS electronic collar leads
- PPG sensor using light pipes
- Custom circuitry for wearable form factor
- Data validated against COTS monitors
- Accurate without shaving the dogs



### 3) Computer-assisted Training:

- Leveraged smart harness, posture recognition algorithms, and remotely operated treat dispensers to provide computer-delivered rewards to dogs
- Explored tradeoff between classification accuracy and response latency
- With response latency below 0.2s (which occurred in two of seven trials) dogs successfully learned to sit to get treats from dispensers without any influence from human handlers



## Year 1 Products:

- Alper Bozkurt, David L. Roberts, Barbara L. Sherman, Rita Brugarolas, Sean Mealin, John Majikes, Pu Yang, and Robert Loftin. Towards Cyber-Enhanced Working Dogs for Search and Rescue. IEEE Intelligence Magazine, Nov 2014.
- Rita Brugarolas, James Dieffenderfer, Katherine Walker, Ashley Wagner, Barbara Sherman, David L. Roberts, and Alper Bozkurt. Wearable Wireless Biophotonic and Biopotential Sensors for Canine Health Monitoring. In Proceedings of the IEEE 2014 Sensors Conference, Valencia, Spain.

## Year 1 Broader Impacts:

Broader impacts activities have focused on dissemination and outreach.

### Outreach

- Hosted 20 high school students and 8 teachers interested in science and technology from NC school system
- Demonstrated “exciting applications” of computer science and electrical engineering to 40 freshmen women interested in STEM
- Supervised two women engineering students (one undergraduate and one graduate)

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### Dissemination

- Media coverage of our work has included:
- Science360 and CISE Discoveries
  - Huffington Post, Discovery News, Yahoo! News, Fox, ...
  - Participated in SmartAmerica Challenge and was selected as one of the highlighted teams.

