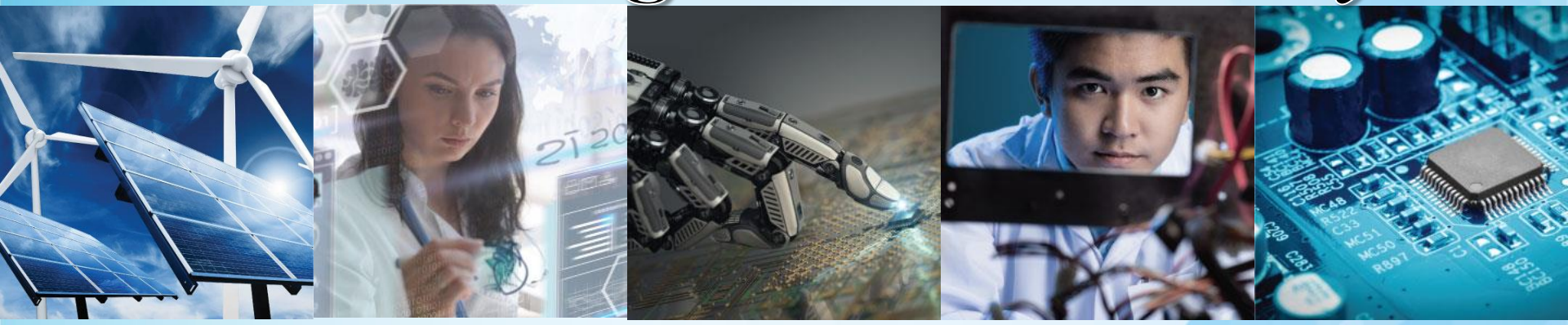
Fitchburg State University



Embedded Sensor Platform for Solar Decathlon

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IEEE
Advancing Technology for Humanity

Outline

- Previous research and relative works
- Current relative works
- Associated Curriculum
- Future works

Our Planet

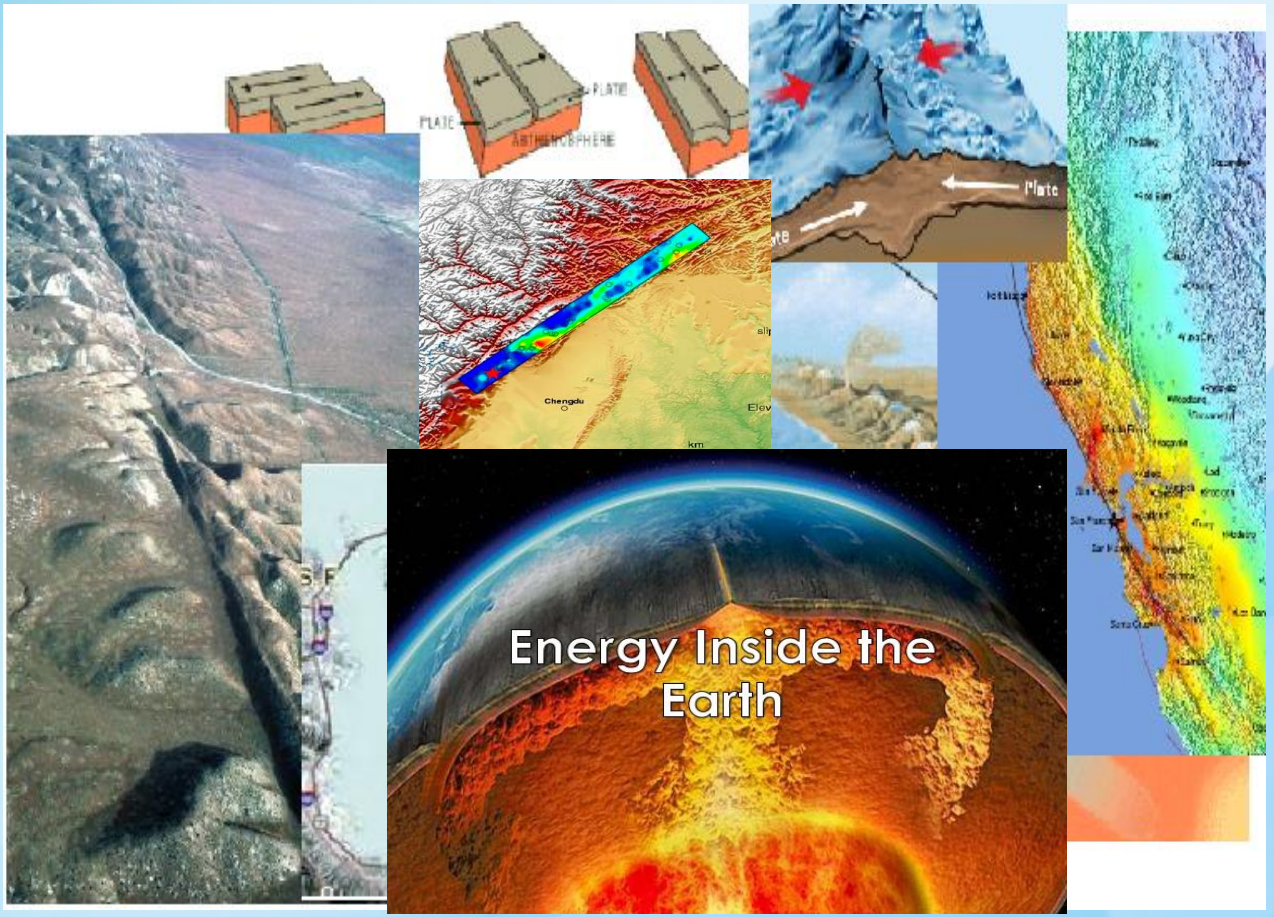
$$iron\ Fe_{56}^{26} = 13x\ He_4^2 + Big\ Bang\ \&\ \text{Curvature Gravity} \quad (1)$$

$$neutron\ N = P^+ + e^- + \nu + heat\ ; \quad (2)$$

- The enormous thermal heat generated by the decay of neutrons, that can melt the iron and neighborhood mantle layer.
- The molten iron core is about the size of the moon.
- The neutron decay heat can expand the molten mantle into upraising convection and change the gravity of the earth.

Earthquakes happened:

(http://www.crystalinks.com/platetectonics.html)



- **Necessary conditions:** Molten Iron Core Cooking Below
- **Sufficient conditions:** Ground faults or cracks.

Earthquakes Happened Everywhere, Every second

- Unfortunately, due to Molten Iron Core cooking insistently from below of the mantle layers of the earth, we can not save the life killed by inevitably large Earthquakes & Tsunamis.

- San Francisco, USA (April,18,1906; 8.0 Richter scale;3,000 dead)

- Sichuan, China (May,12,2008; 7.8 Richter Scale;80,000 dead)

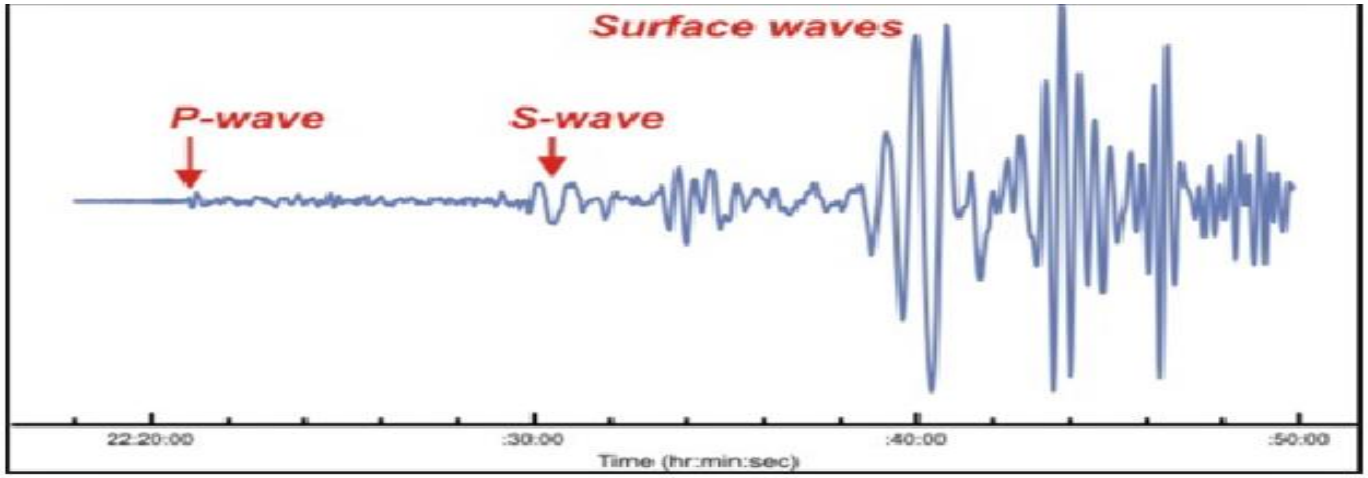
- Fukushima,Japan(March,11,2011; 9.0 Richter Scale;);Nuclear Power Plant Meltdown;, 15,894 dead, 2561 lost due to mad evacuation;

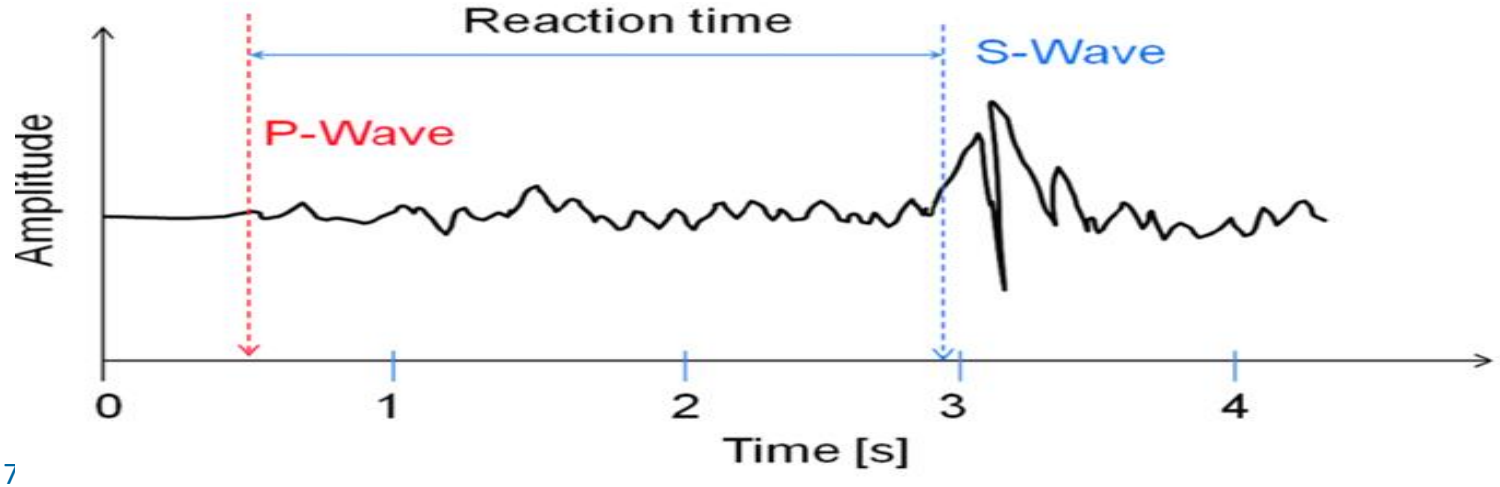
“Life is in Seconds Count” by Nowcast

- The used models forecasted earthquake weeks or months early seem not to be effective since the life must go on
- Forecasts seems not so useful but Nowcast is
- For our human, few seconds or minutes ahead to save more life during earthquake
- Prof. Richard Allen of UC Berkeley has summarized the Nowcast well: “The United States should install an earthquake early-warning system now before the next big one hits.”

Seismic Wave Frequency

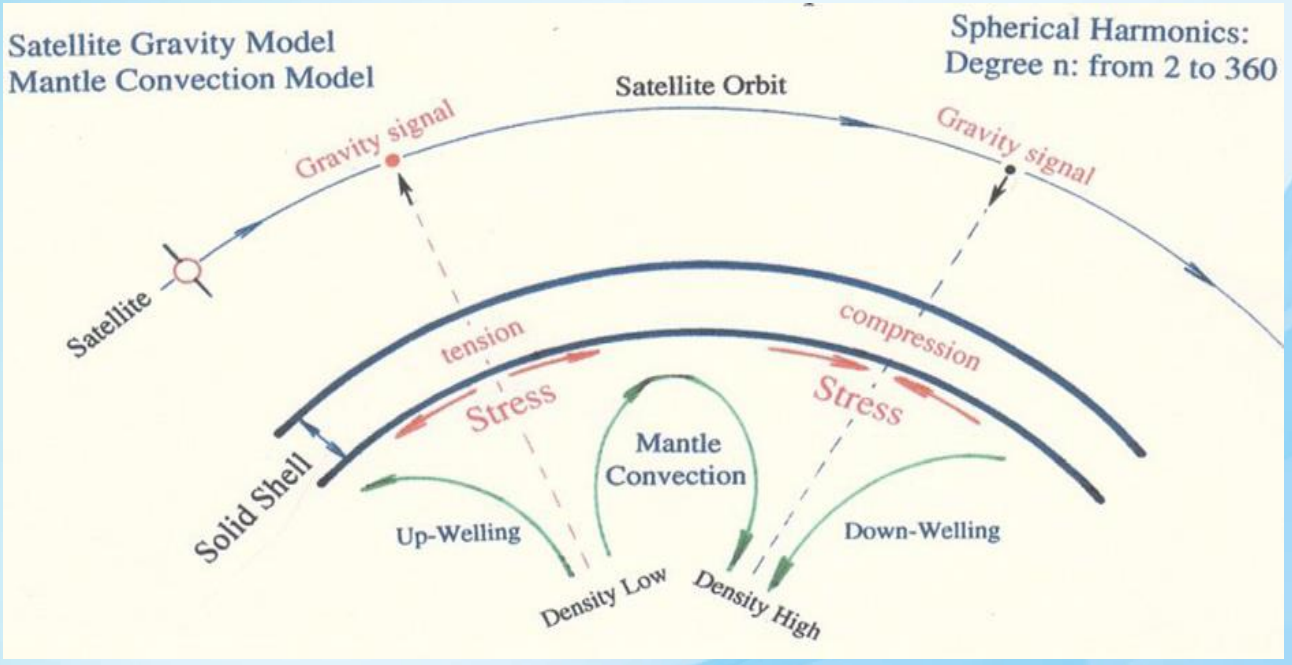
- Earthquake frequency between S waveform and P waveform

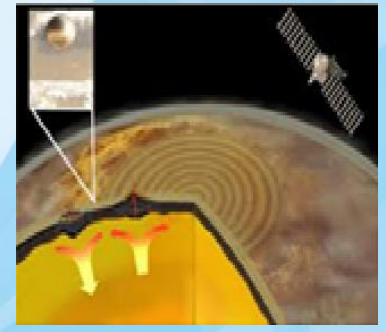




Forecast with The Probability versus Nowcast with The Possibility/Certainty

- ***In this research, we design an intelligent Vertical integration science technology acceleration (i-Vista) & an intelligent Horizontal integration science technology acceleration (i-Hista).***





Nowcast requires Smartphones everywhere with USGS ground measurement and NASA Satellite

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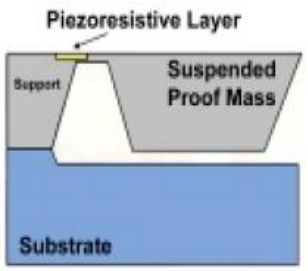
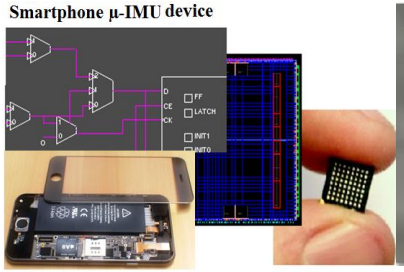
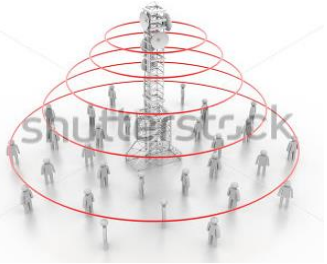
Smartphones, Satellites, UAVs, Grounds

- Smartphones need μ-IMU made of 3-D Gyro suspending a proof mass within a Piezoelectric soft crystal that can generate voltage changes when the gravity changes for ***(i-Vista)***

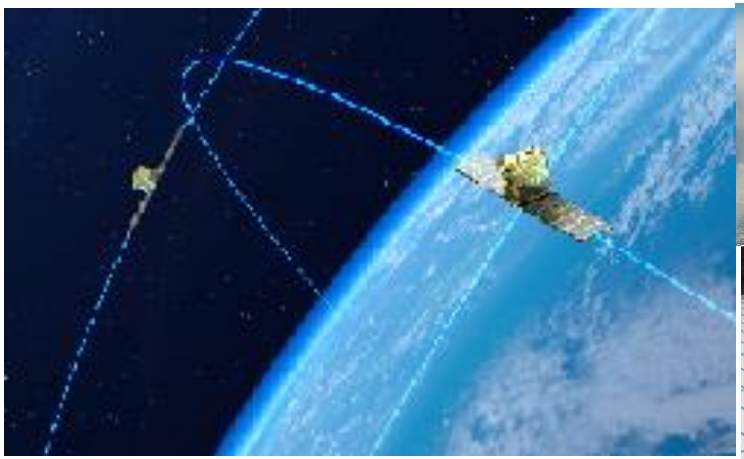


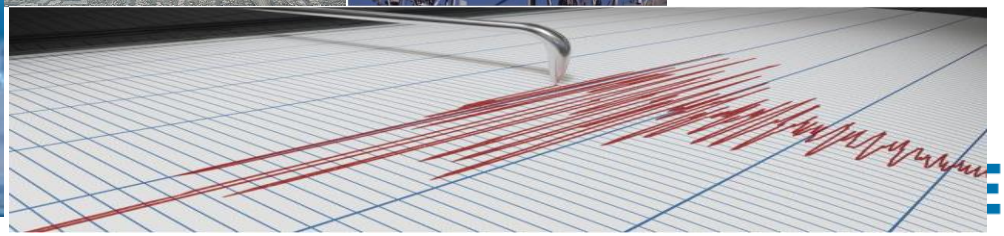




IMU--- Inertial Measure Units

- μ-UAV in-situ gravitation force measurement by Satellites, UAV, Ground for ***(i-Hista)***

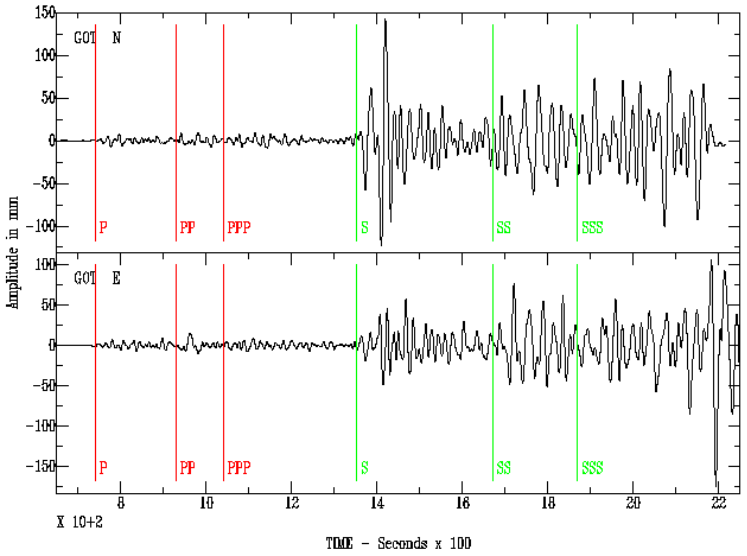




UAV--- unmanned aerial vehicle

Nowcast Mathematics

- Smartphone IMU pro-processing: Auto Associate Memory (AAM), Hetro-Associative Memory (HAM)
- HAM--Write by vector outer product (among early experimental Smartphone IMU data from UAV); The decision about Earthquake ground truth at a Richter scale (3~9);Ascertained by the μ-UAV in-situ gravitation force measurement
- Current Smartphone IMU gravitational vibration data over the minute segment can be "read by the matrix vector inner product of new incoming data" about the Nowcast of whether the Earthquake IMU data implies a potential Earthquake at what Richter scale.



Write to the storage:

$$[HAM] = \sum_{i,j} \left[\vec{Y}^T(Richet, time\ segment_i) x \vec{X}(IMU\ vibration\ data_j) \right]$$

Read from the storage:

$$\vec{Y}_i'(Richet, time) = \sigma\left([HAM] \vec{X}_k'(IMU\ vib\ data) \right)$$

Nowcast Mathematics

- The precursor Seismic Wave Time Series (SWTS) template is, e.g. $\hat{S}^{(1)^T}$ =(1, 3, 5, 7, 0, …), while the other templates is $\hat{S}^{(2)^T}$ =(0, 2, 3, 2, 0..). Mathematically, the coordinate's $\left\{\hat{e}^{(n)}\middle| n = 1,2\right\} = \{(1,0,..)^T \; and \; (0,1,..)^T\}$ to achieve in effect a line-by-line Associative Memory $[AM]$ Matrix storage

$$\begin{bmatrix}1\\0\end{bmatrix}[1 \quad 3 \quad 5 \quad 7 \; 0 \ldots.] + \begin{bmatrix}0\\1\end{bmatrix}[0 \quad 2 \quad 3 \quad 2 \; 0 \ldots.] = \begin{bmatrix}1 & 3 & 5 & 7 \; 0 \ldots.\\ 0 & 2 & 3 & 2 \; 0 \ldots.\end{bmatrix} \equiv [AM]^T$$

Archival $Write$: $[AM] = \sum_{n=1}^{dof}[\hat{e}^{(n)}\vec{S}^{(n)^T}]$;

$$[AM]\hat{e}^{(1)} = \begin{bmatrix}1 & 0\\ 3 & 2\\ 5 & 3\\ 7 & 2\end{bmatrix}\begin{bmatrix}1\\0\end{bmatrix} = \begin{bmatrix}1\\3\\5\\7\end{bmatrix} = \vec{S}^{(1)}; \; [AM]\hat{e}^{(2)} = \begin{bmatrix}1 & 0\\ 3 & 2\\ 5 & 3\\ 7 & 2\end{bmatrix}\begin{bmatrix}0\\1\end{bmatrix} = \begin{bmatrix}0\\2\\3\\2\end{bmatrix} = \vec{S}^{(2)}$$

We can compare the incoming Smartphone new SWTS with the precursor template library [AM] by matrix vector inner product

$$Nowcast\ Read: \; \theta\{[AM]\widehat{new}\} = \vec{S}^{(n)^T} \; if \; n \in precursor \; or \; not$$

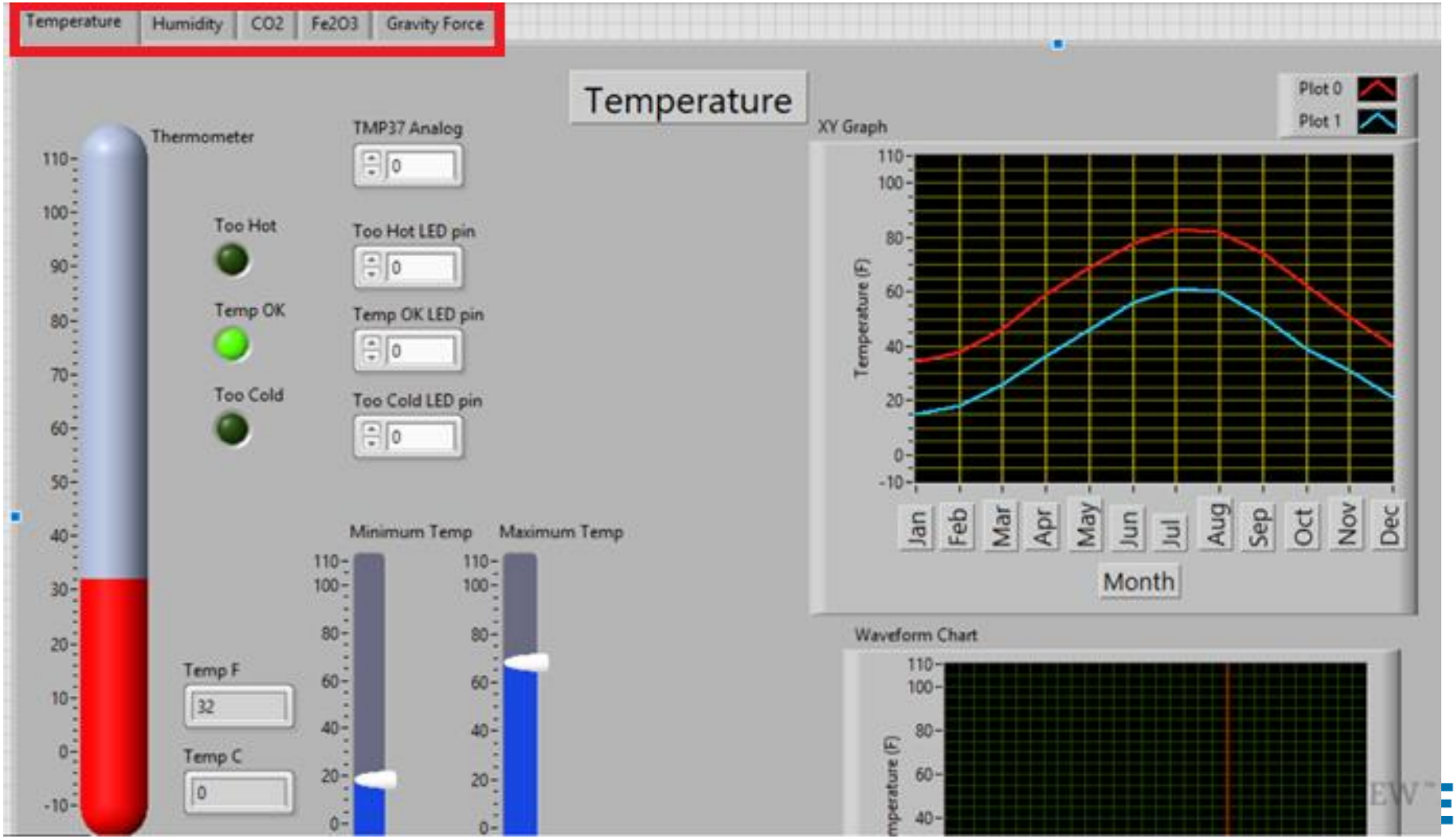
Nowcast system processing

- Earthquake early-warning technology (an automatic warning was issued within seconds) is proven. Japan leads the way.
- A magnitude 6.5 earthquake struck in Kumamoto, Japan on April 14, 2016; A magnitude 7.3 earthquake struck in Mashiki, Kumamoto, Japan on April 16, 2016;
- There are **50** dead, **3000** injury and 100,000 homeless totally.

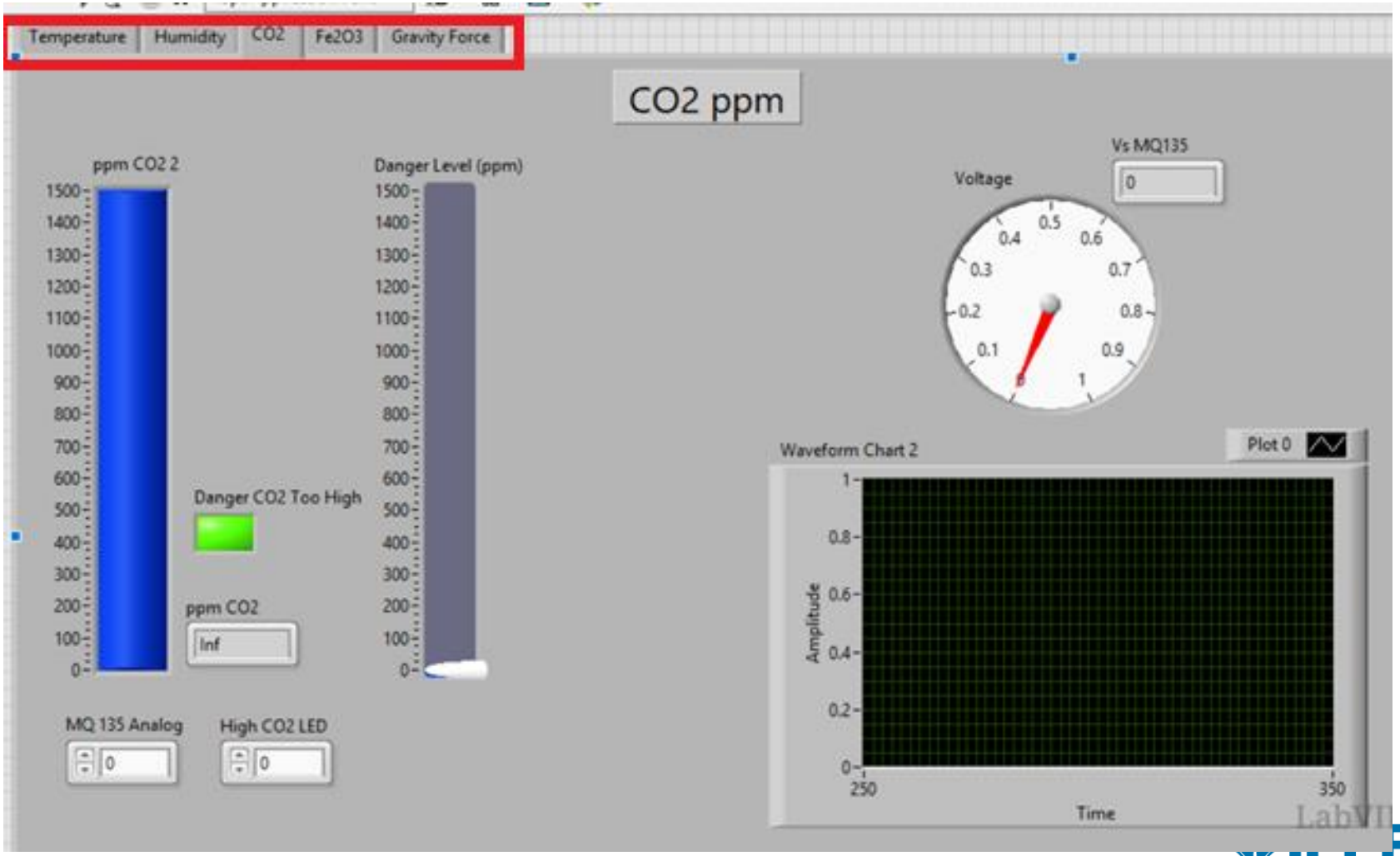
Current relative works

We need a platform with multiple embedded sensors for environment monitor system such as Solar Decathlon

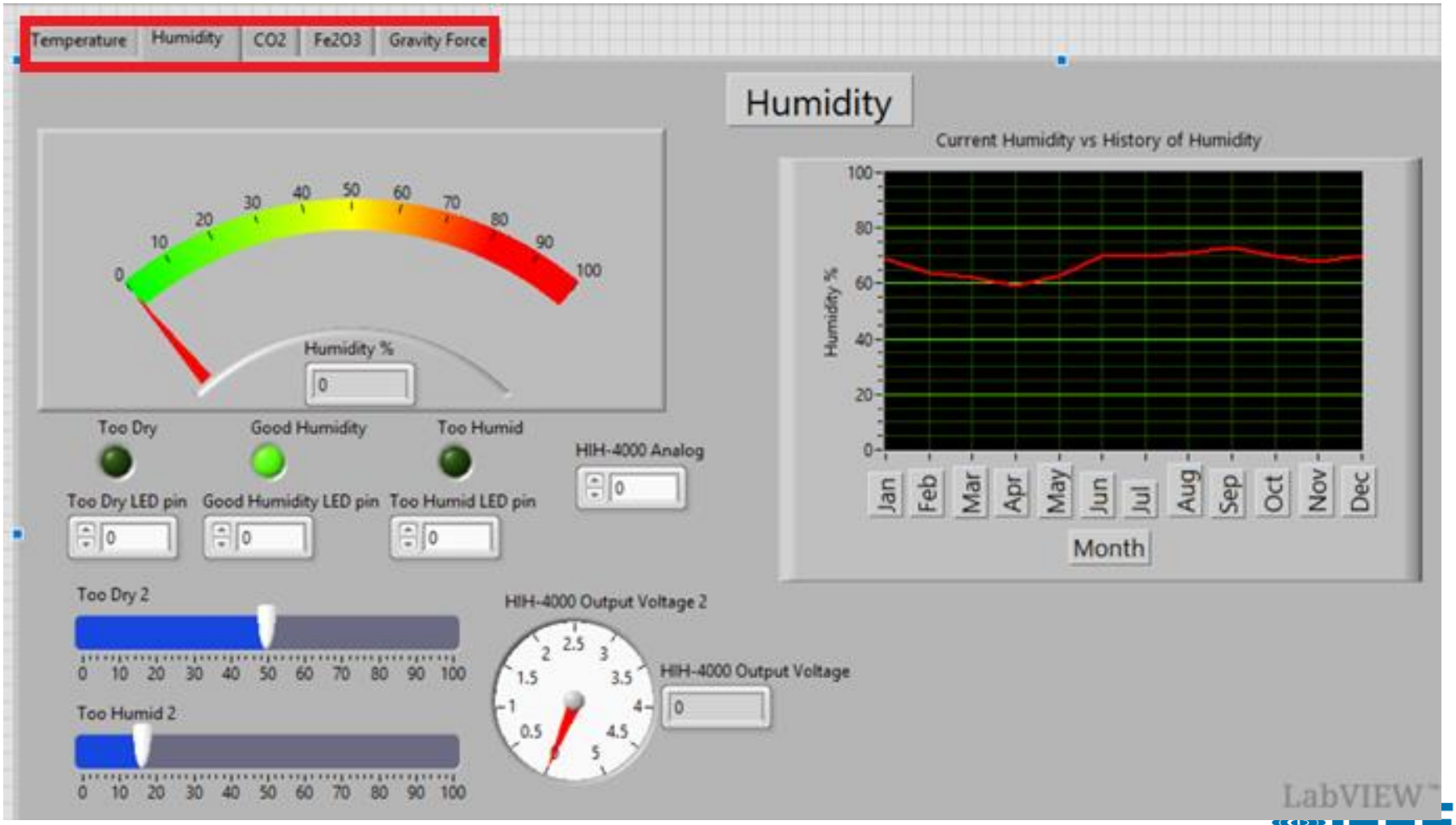
Multiple Embedded Sensors System Performance Platform for Environmental Monitor System



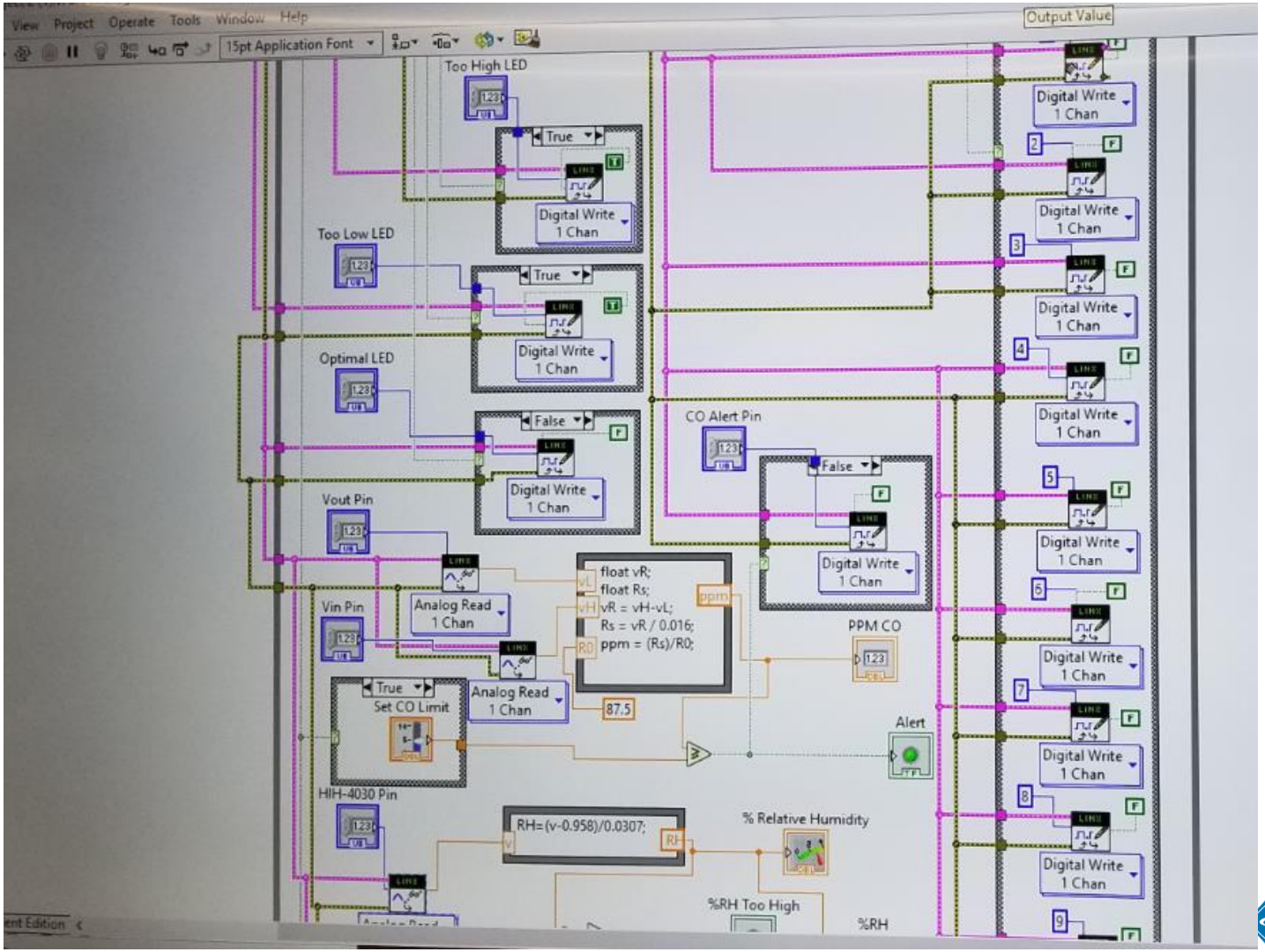
Multiple Embedded Sensors System Performance Platform for Environmental Monitor System



Multiple Embedded Sensors System Performance Platform for Environmental Monitor System



Code of the platform



Associated Curriculum

- ENGT1000
- ENGT2055
- ENGT3900
- ENGT4050

Future relative work

Sync smart phone data…

Q & A

Thank you for your coming!