EARTHQUAKE PREDICTION AND MOBILE TECHNOLOGY

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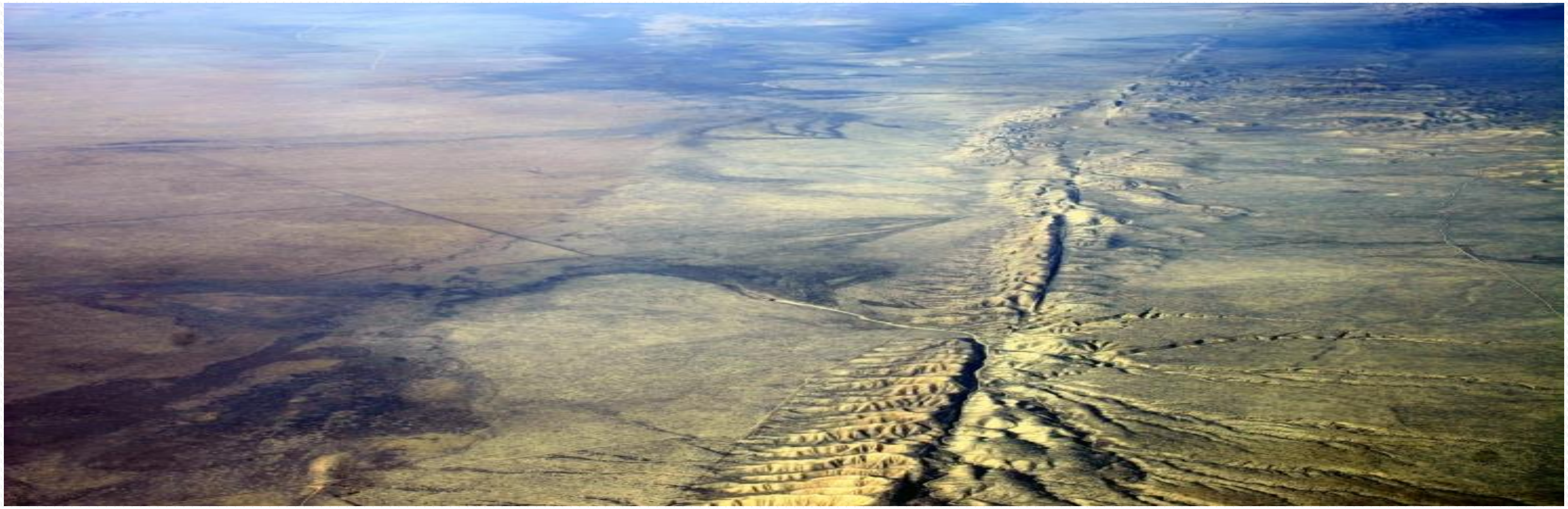
Earthquake

- An **earthquake** is the result of a sudden release of energy in the Earth's crust that creates seismic waves.



- It causes loss to human and animal life.
- Capable of causing large scale destruction.
- Earthquakes are measured using observations from seismometers

The Idea of Earthquake Prediction

- **Time-independent hazard:** Random process in time, used for building design, planning, insurance, probability.

- **Time-dependent hazard:** A degree of predictability, enable authorities to prepare for an event-**false alarms-loss of public confidence**.

Earthquake Prediction or Forecasting

- Precursor detection instruments at the site.
- Detect and recognize precursors.
- Get colleagues to agree, accept and put out a warning.
- **Earthquake forecasting:** Some connection between the level of chance between observation and event probabilities where errors are involved.

Early Warning System

- Detect P-wave arrival.
- Warning system.
- Emergency centers, hospitals railways.
- Depends on distance to how helpful.

- **Japan**: March 2011, M9 Quake, Tokyo-stopped trains; Cell phone notification; 8-10 minutes tsunami.

Waves

- Types of waves resulted after ground movement:
  - P waves
  - S waves

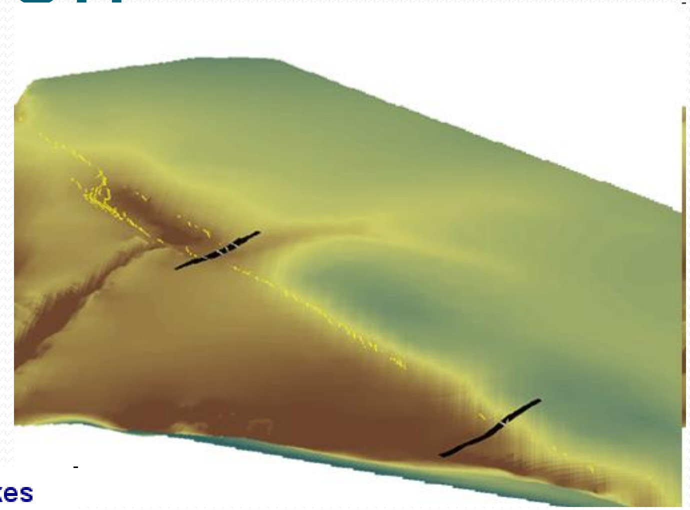
- P-waves propagate similarly to sound waves by alternating between compressing and dilating in the same direction that the wave is traveling.

- This longitudinal motion compresses the earth's crust as it moves but causes very little or no destruction.

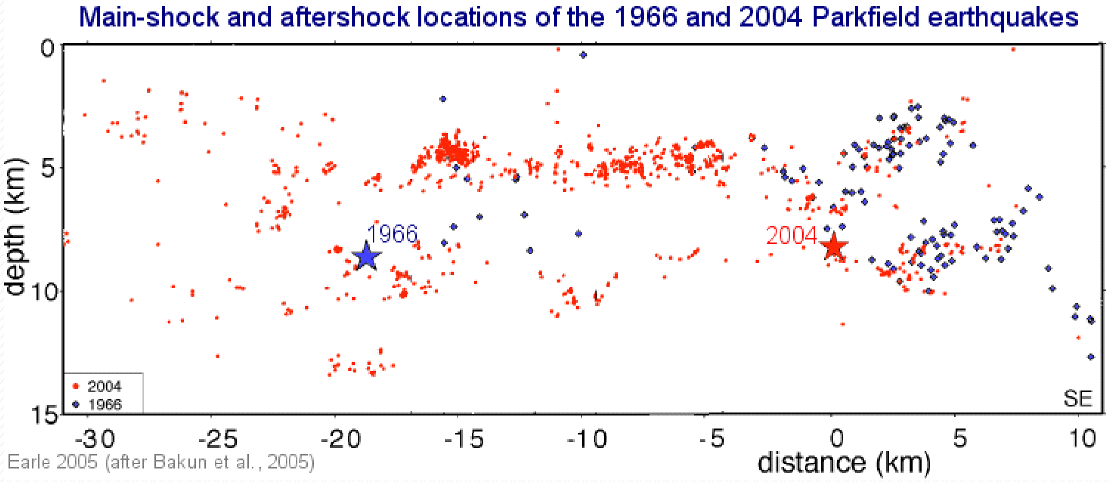
- These waves travel at a speed of 4-7km/second and can move through gas, liquid, and solids.
- These waves can move through the molten core of the Earth (P-Waves and S-Waves).
- P-waves move faster than s-waves and can be used to detect the onset of an earthquake before the arrival of the more destructive s-waves.

Precursors to observe for earthquake prediction

- Ground deformation
- Foreshocks



Surface cracks associated with the 2004 earthquake



Radon gas emissions

- Radon is a natural radioactive gas.
- We cannot see, hear, feel, or taste it. It comes from the minute amounts of uranium that occur naturally in all rocks and soils.
- Radon emission- sometimes shows an increase preceding an earthquake.
- There was a ten-fold increase 30 kilometers away from the epicenter 9 days preceding the earthquake.

Statistical Methods

Recurrence Frequency

- Relationship between the magnitude and repetition of earthquakes.
- Assumes that the same set of conditions leading to an earthquake occur each time.
- Dependent on large amounts of historical data.

Seismic Gap Theory

- Focuses on patterns in seismicity.
- Predicts based on irregular activities.
- Also if there is a large gap in activity on an active fault.
- If a change in the pattern occurs, there is a chance for an earthquake.

Physical and geophysical measurements

- Studies of precursors and events that occur before an earthquake.
- Increase in the rate of a seismic creep and the slow movement along the fault .
- Gradual tilting of the land near the fault zone .
- Drop or rise in the water level of a well .

- Decrease in the number of micro quakes and foreshocks.
- Flashes and other lights in the sky.
- Animal behavior.
- Unusual migration or movement of birds and animals.
- Sudden drop or rise in the water level of wells or even sea.

Fault Creep Measurements

- Measures the slow rate of movement on the fault.
- Where lots of fault creep occur there is a small chance of a big earthquake.
- Where little amounts of fault creep occur there is a high chance of a big earthquake

Drop or rise in the water level of a well

- Large amplitude surface seismic waves force the particles of the rock near the surface to move adjusting the level in the well.
- Before an earthquake water wells are also affected by any fault creeps, crust tilts, or other seismic activity.
- Drilling wells in certain locations and measuring the water level and quality can aid in earthquake predictions.

Animal behavior

- Recognizing unusual animal behavior in a systematic way can be used to predict earthquakes.
- The Chinese started recording unusual animal behavior and successfully predicted an earthquake in 1975 3 months before it struck.

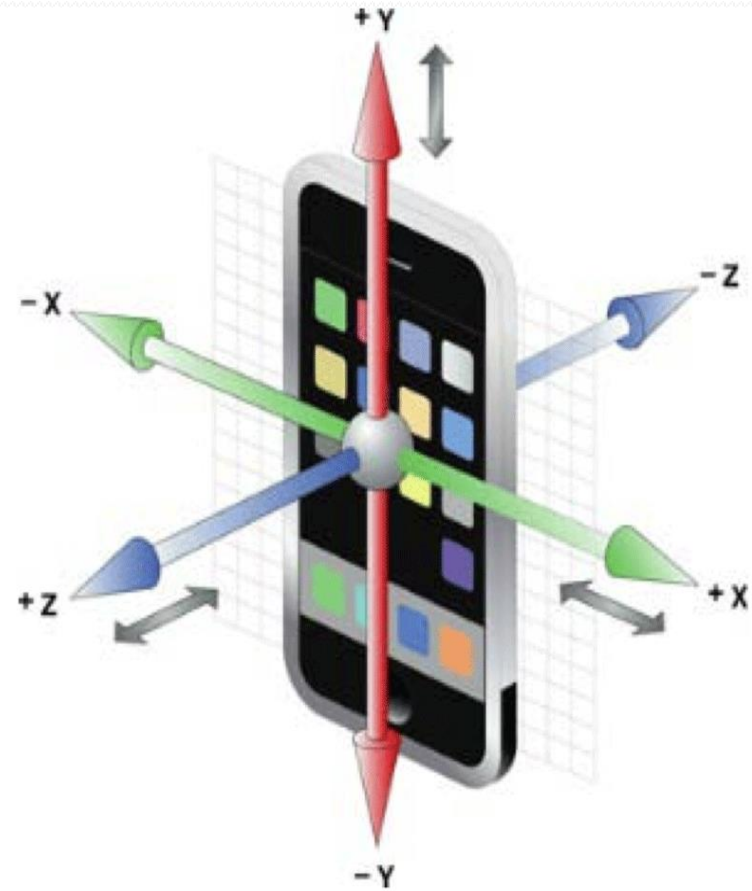
Observation factors :

- Hibernating animals leaving their underground nests.
- Animals refusing to go into pens.
- Animals seeking higher ground.
- Birds vacating the area.
- Deep water fish come closer to the surface.

Problems

- Requires a lot of data collection and data mining to find patterns.
- Popular methods used around the world.
- Problem with these precursors is that some of them are geographically specific.

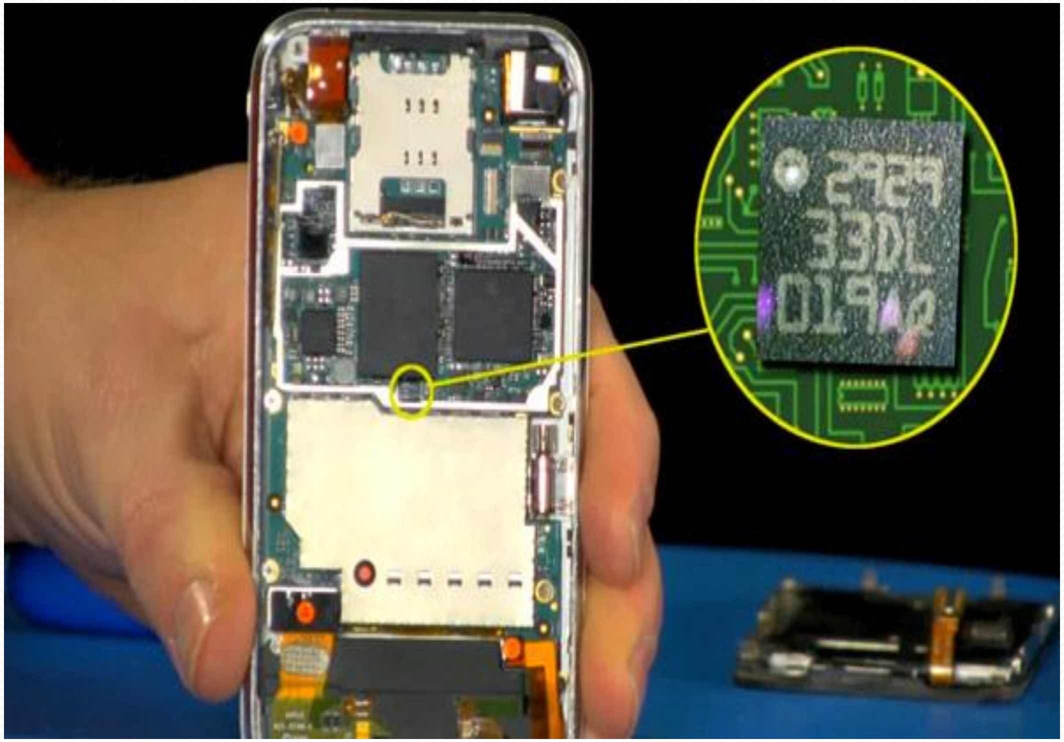
Mobile sensors



- Collecting precise real-time data on earthquakes is a very difficult job.
- Scientists appear to have found a better tool for sensing earthquakes:
  the Accelerometers in today's Smartphone's.

- An accelerometer is a device that detects its own acceleration.

- The typical accelerometer used In digital devices, can detect acceleration on two or three axes, allowing it to sense motion and orientation.



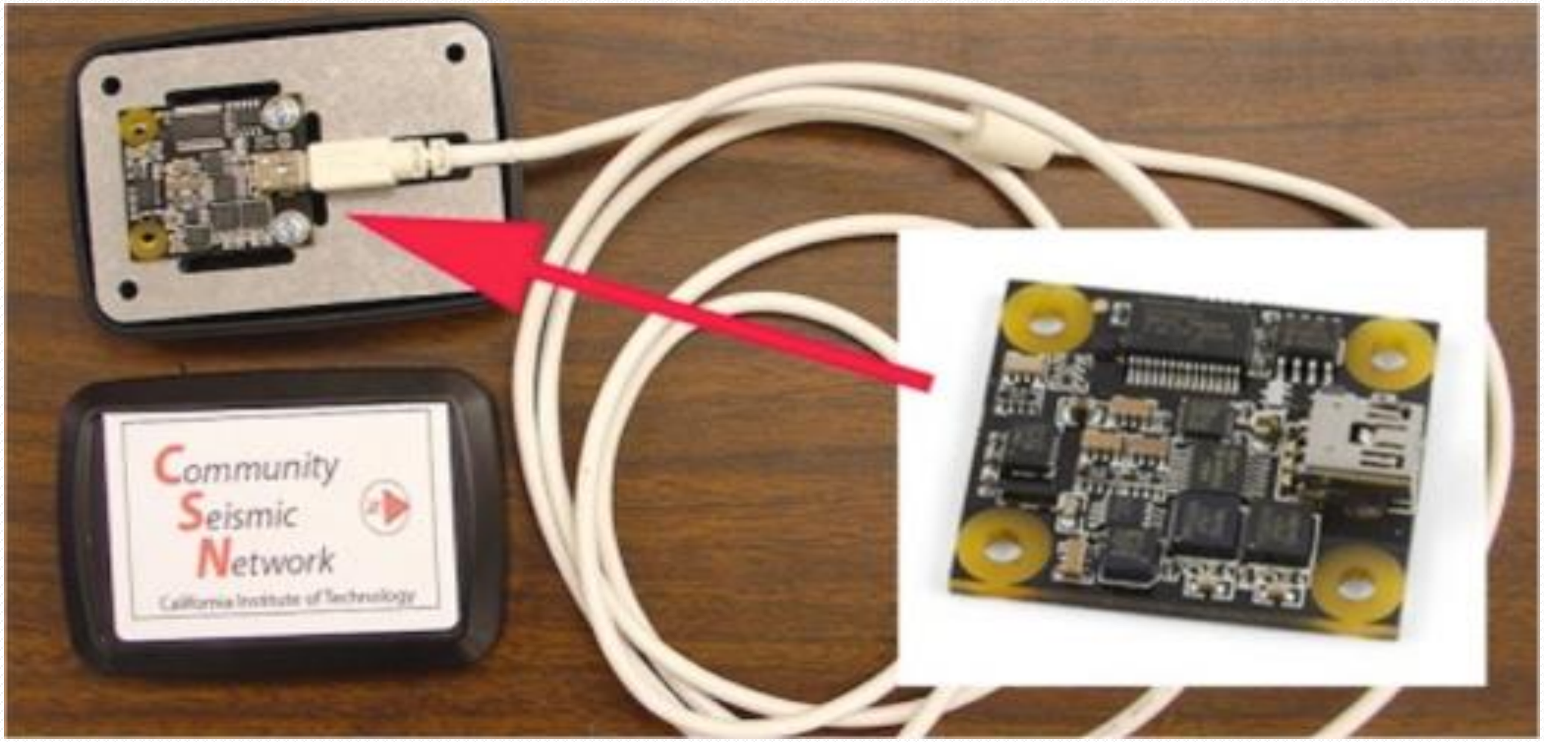
- Accelerometers found in most smartphones and laptops are sensitive enough to detect the movement of moderate and large earthquakes.
- The Micro Electro-Mechanical Systems (MEMS) accelerometer is a chip found in most smartphones and laptops.
- It can be used to monitors the rate of acceleration of ground motion as well as vibration of cars, buildings and installations.

Community Seismic Network

- Millions of Internet-enabled devices like phones, laptops, and game consoles now have accelerometers that can be used to detect and measure earthquakes.
- Harnessing the data from these sensors could allow us to quickly detect large earthquakes, and accurately estimate where damage has occurred and where emergency responses are needed shortly after a quake.
- However, processing the data from a city-wide sensor network is a challenging Internet scale problem involving real-time analysis of many noisy sensor measurements.

- We can create an “urban seismic network” by using several Smartphone's accelerometer readings.
- A network created by connecting seismographic equipment to volunteer computers.
- Multiple sensors required which are more sensitive to detect earthquake.
- Focuses on large numbers of inexpensive, community-held sensors, such as those in personally owned devices like smart phones.

- CSN-Droid, a free and open source Android App, allows volunteers to join the network and contribute accelerometer measurements



Large scale processing in the cloud

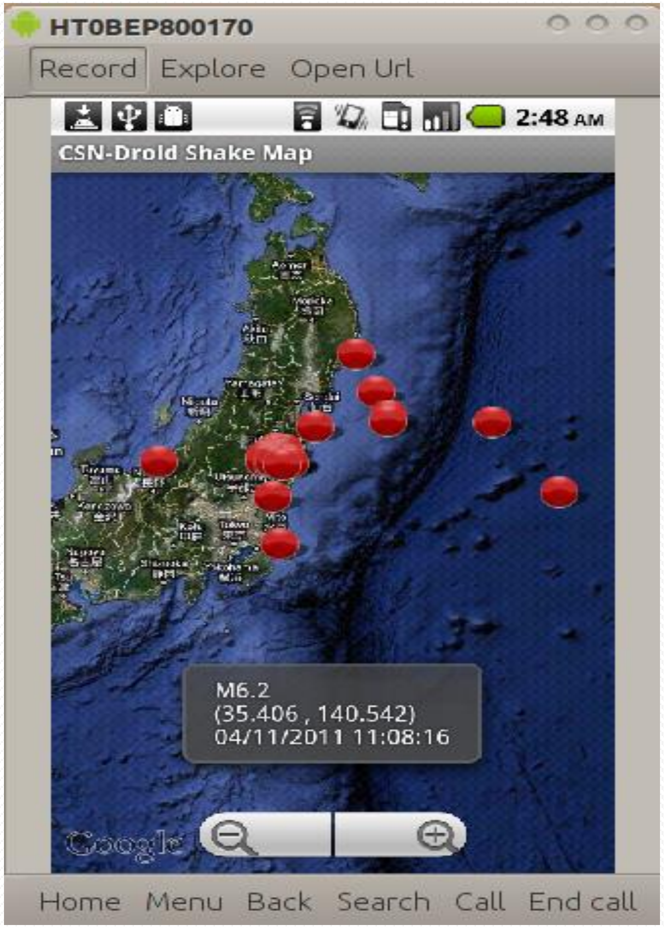
- City-wide networks of community-owned devices, and is developing scalable techniques to process the enormous amounts of data that such networks would produce.

- For example, if only 1% of Smartphone's contributed sensor data, the network would need to process hundreds of thousands of continuous data streams.

- Data processing across the individual sensors and performs central processing using Google’s App Engine cloud computing platform.

- Initial processing at each sensor is used to filter normal sensor data, and only use bandwidth for transmitting potential seismic measurements.
- These selected measurements are processed on App Engine, which allows processing power to be rented on an as-needed basis.
- This allows large network loads such as during an earthquake to be handled easily, without requiring maximum capacity on a day-to-day basis.

Sensor data collection



Sensor readings worldwide

iShake project

- The iShake project develops the insights required to create a more objective, quantitative, rapid, and accurate assessment of the distribution of ground shaking during a major earthquake.

- Emergency responders must "see" the effects of a major earthquake clearly and rapidly so that they can effectively respond to the damage it has produced.

- The app measures the earthquake and figures out its magnitude.
- It then sends that information to a central server so that scientists can study the data and map out the earthquake's scope and damage.
- What makes this technology so useful is that it already exists, and nearly everyone has a Smartphone.
- Takes advantage of the accelerometers most people have already in their cell phones.

- It collects ground motion intensity parameters during the earthquake.

- An accurate portrayal of the damage effects of an earthquake can be provided to government officials and emergency responders immediately after an event.

- Through iShake people will be able to make use of their own smart phones and participate in an effective and valuable process to inform emergency responders in the event of an earthquake.

Conclusion

- No 100% accurate way to predict an earthquake.
- As more data is collected, predictions will get better.
- From data mining, more patterns will be found increasing the accuracy of predictions.
- However, with smartphone technology advancing every day, the we believe that Smartphone's will be able to detect earthquakes in the future.