Name: Mohammad AlAdwani / Deliverable #1

1. Project Proposal:

Understanding California's Earthquakes

The Working Group on California Earthquake Probabilities (WGCEP) is lately considering in its models complex multi-segment rupture scenarios where earthquakes are no longer confined to separate, individual faults but can rupture multiple faults simultaneously on occasion. This reflects what seismologists have been observing from earthquakes around the world concerning the complexity of dependent fault interactions and stress triggering at depth for faults where, at the surface, these factors appear to be independent. That is, it seems like assuming a given earthquake comes from rupture in a nearby fault may be too simplistic in many occasions. In the contest of dealing with induced seismicity studies in complex geological scenario, the idea of being able to better understand how earthquakes can be generated from multiple faults from observed data is very appealing (so we can better condition our computational models).

The general theme of this project is working with historical earthquake data in California. The first piece of data under consideration will be all earthquakes in that region with magnitude more than 3.5 over the last 20 or 25 years, which means thousands of earthquakes. These data are available to download from the IRIS repository. The second piece of data that I'll be looking at will be an active fault map for the California region, which is available in many websites. The basic idea of this particular project would be to find some patterns or trends between the fault lines and the reported earthquakes (characterized by their time, magnitude and location). Either temporal and spatial relationships (preferably both) should be the aim for this work. Within this general idea many things could be tried and tested. From the perspective of visualization, I can create some visualizations such as showing earthquake epicenters and illuminating closest faults in a dynamic video or I can even generate an earthquake-energy density map. From the algorithmic point of view, I can try clustering earthquakes using soft clustering techniques such as "Fuzzy Clustering", so that we allow individual earthquakes belong to several clusters simultaneously (with different strengths). Each cluster can be representative of a major fault, or perhaps a major orientation. The goal of this project is to see if we can identify some of these complex multi-segment rupture trends.

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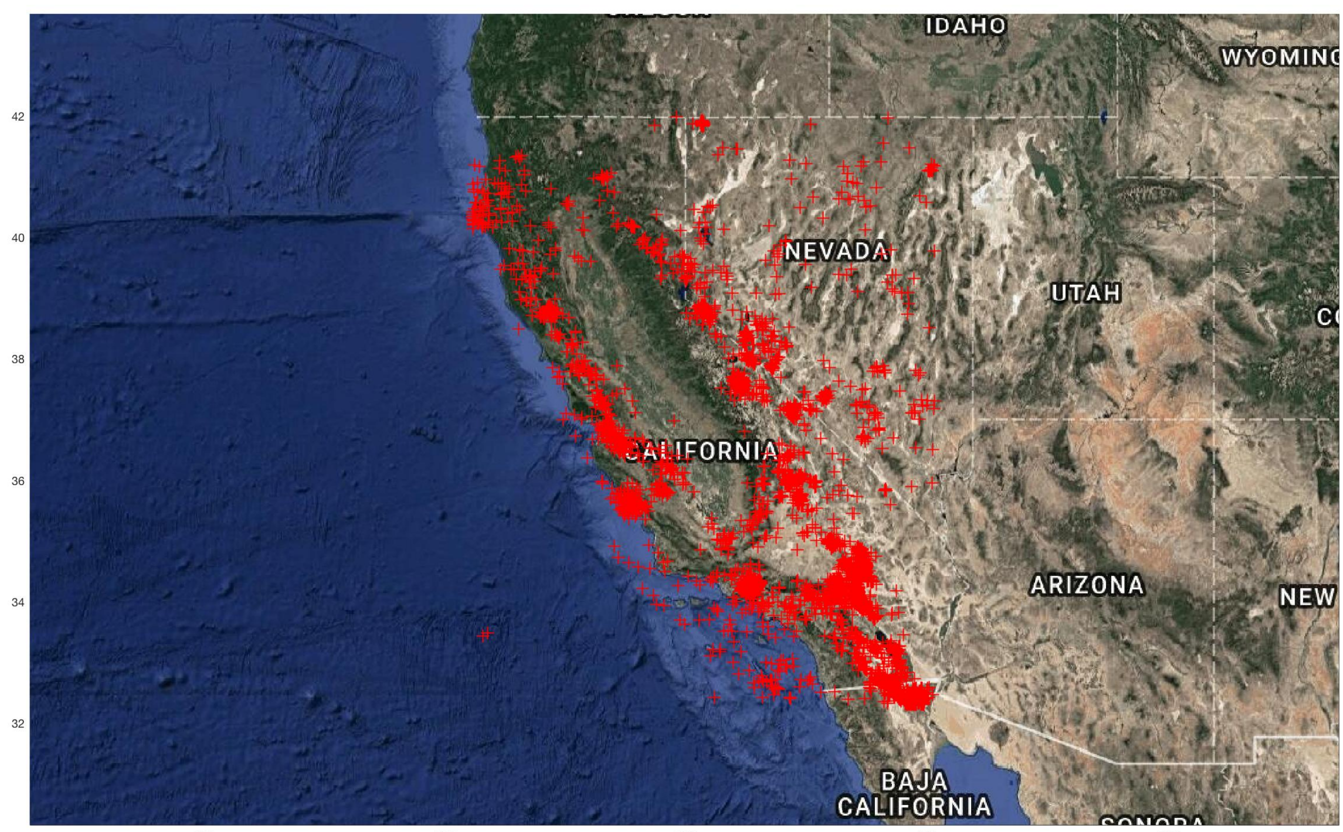
2. Modules Used, Technology Demonstrations and Code Artifacts:

MATLAB’s Mapping Toolbox and Google Maps

Understanding California’ earthquakes will be done mainly in MATLAB, which has multiple functionalities that are suitable for this project. For example, MATLAB’s Mapping Toolbox is a great tool that allows manipulation of the world map and overlapping relevant data on the selected map. In addition, MATLAB has a function plot_google_map.m that is available online, which uses the Google Maps API to plot a map in the background of the current figure. It assumes the coordinates of the current figure are in the WGS84 datum, and uses a conversion code to convert and project the image from the coordinate system used by Google into WGS84 coordinates. The zoom level of the map is automatically determined to cover the entire area of the figure. Additionally, it has the option to auto-refresh the map upon zooming in the figure, revealing more details as one zooms in. Using MATLAB and earthquakes data that I’ve obtained from the IRIS repository which were processed into a suitable format for MATLAB, I’ve produced the following plot of earthquake locations in California (plus Nevada), which demonstrates competency in MATLAB and the relevant tools.



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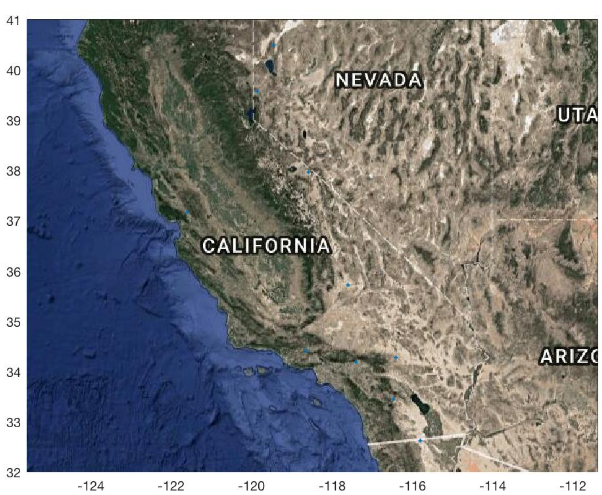
3. Storyboard:

Earthquakes’ Risks and Future Insights

Although ground shaking itself may not be dangerous given the modern resilient infrastructures, the effects of earthquakes extend beyond property damage. For example, large rocks and portions of earth high up in the hills, during an earthquake, can become dislopdged and rapidly roll or slide down into the valleys. Landslides on mountains can cause serious damages and pose risks on human lives. In addition, earthquakes can cause fires as escaping gas from broken gas lines and the toppling of containers with flammable substances (e.g. kerosene.) present a significant threat of explosions. Not only explosions can be caused by earthquakes, but also floods. Earthquakes can cause dam walls to crack and eventually collapse, sending raging waters into surrounding areas and causing severe flooding. More bizarre than floods are tsunamis, which are generated by earthquakes with a Richter magnitude exceeding 7.5. Deadly tsunamis occur about every one to two years and they have at times killed thousands of people; therefore, understanding earthquakes and being able to predict future events is a valuable tool that can save both lives and money. The ultimate goal of this project is building a model with high accuracy that can predict location, time and the magnitude of the next upcoming earthquakes. However, building the full model is outside the scope of this class.

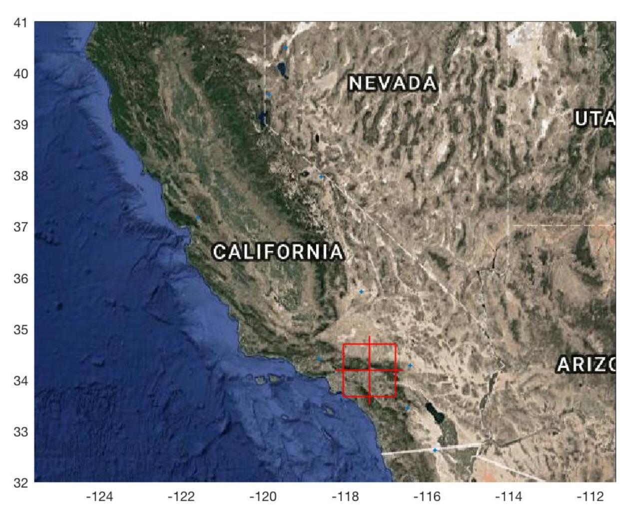


Earthquakes Forecast

Date: November, 10, 2016
Earthquakes: 0
Location: -
Magnitude: -

Earthquakes Forecast

Date: November, 19, 2016
Earthquakes: 1
Location: (-117.4080, 34.1877)
Magnitude: 6.5



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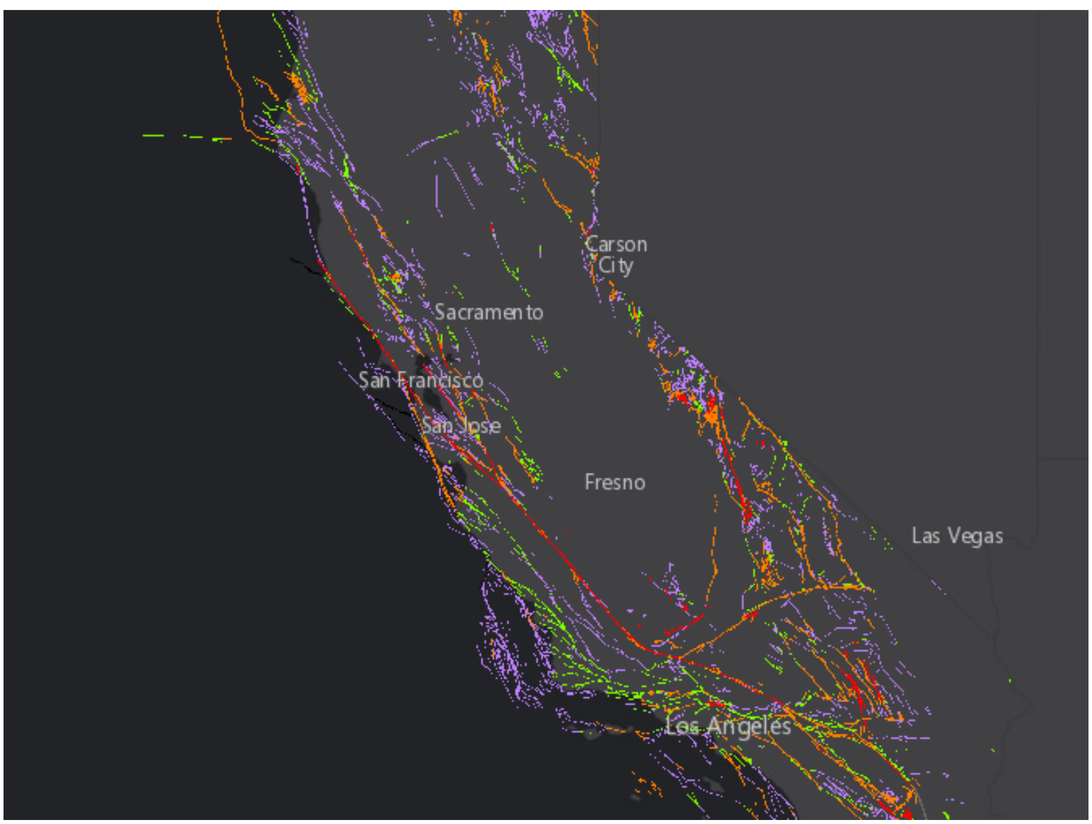
4. Competitive Analysis:

Methods to Tackle the California Problem

Many universities have looked at the California problem and at the IRIS earthquake data; however, no one was able to come up with an accurate model that can predict future earthquakes' locations, times and magnitudes accurately. Caltech in particular is looking at the problem extensively. I'm not expecting to solve the California problem, but rather get insight into the problem and extract some new information from the data. This problem has been tackled by several institutions using several tactics that utilize linear programming, machine learning, bayesian inference, neural networks and principal component analysis (PCA). In the following page are a few references that tackle the same problem that I do. Despite the fact that there are many people who are tackling the problem via creative ways, there is a room to study the problem from a different prospective. I'll try to link Earthquakes data with fault locations in California and take it from there. Below is a figure of California's fault map which I screen-captured from the ArcGIS website. I'm planning to study this figure along with earthquake data, come up with a simple clustering technique that gives some insights into the California problem.



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5. Timeline:

1. Studying the data from the IRIS repository, extracting relevant data for the study and putting needed data in MATLAB's format. **(27 hours)**
2. Reading the following references to see what other people have tested and come up with. It's a useful exercise to generate new ideas. **(18 hours)**
    - H Adeli, A Panakkat, A probabilistic neural network for earthquake magnitude prediction, Neural Networks, 2009 Elsevier.
    - CK Oh, JL Beck, M Yamada, Bayesian learning using automatic relevance determination prior with an application to earthquake early warning, Journal of engineering mechanics, 2008.
    - A. Alimoradi, JL Beck, Machine-Learning Methods for Earthquake Ground Motion Analysis and Simulation, Journal of Engineering Mechanics, 2015
3. Understanding the functionalities and the usage of MATLAB's Mapping Toolbox and how to use google maps in MATLAB. **(7 hours)**
4. Plotting Earthquake data in MATLAB, creating a time series video of earthquake events in MATLAB along with classification of earthquakes by magnitudes. **(3 hours)**