Use Cases in AI and Machine Learning

Rao Vemuri
rvemuri@gmail.com

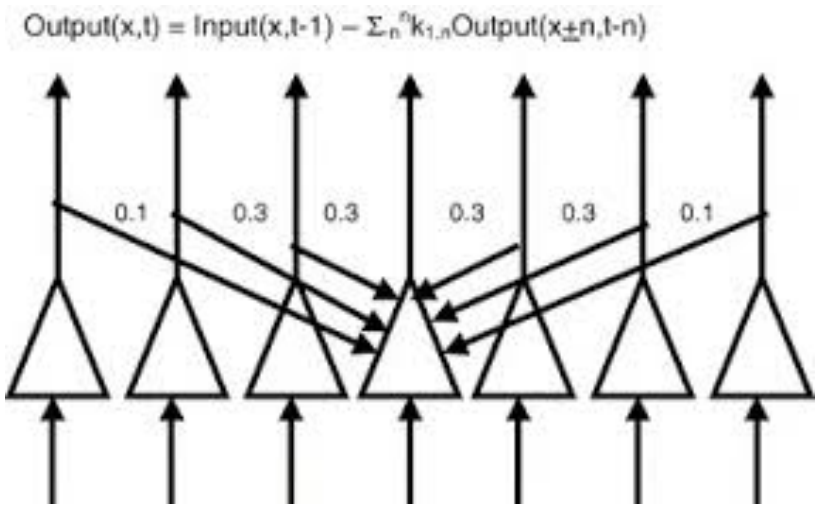
1. Lateral Inhibition & Mach Bands

- Circa 1964
- The experiments on cats at the Brain Research Institute at UCLA
- To study the phenomenon of Mach Bands
- My simulation of Mach Bands on Beckman EASE analog computer
- The architectural similarity with the Hopfield Net (invented in 1983)

Mach Bands & Lateral Inhibition

Mach bands is an optical illusion named after the physicist Ernst **Mach**. It exaggerates the contrast between edges of the slightly differing shades of gray, as soon as they contact one another, by triggering edge-detection in the human visual system.

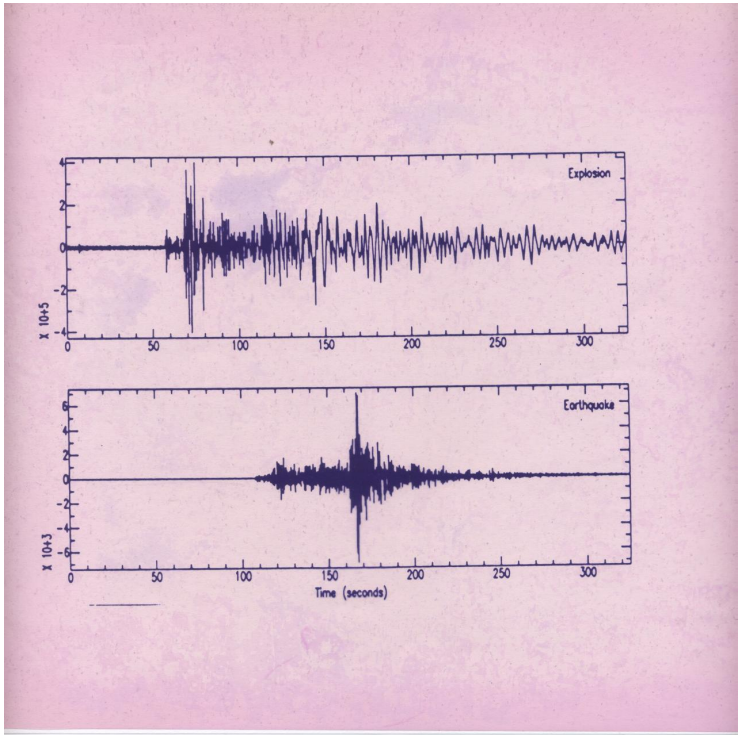
Simulation of Lateral Inhibition on an Analog Computer



2. Nuclear Explosions Vs Earthquakes

- C 1986
- Comprehensive Test Ban Treaty Verification (CTBTV) Project at LLNL
- Built a 3-layer 8-3-8 NN to detect explosions
- Difficulties in training (Asymmetric data)
- Simulated data created on Earth Model
- Can we use the technology to forecast earthquakes?

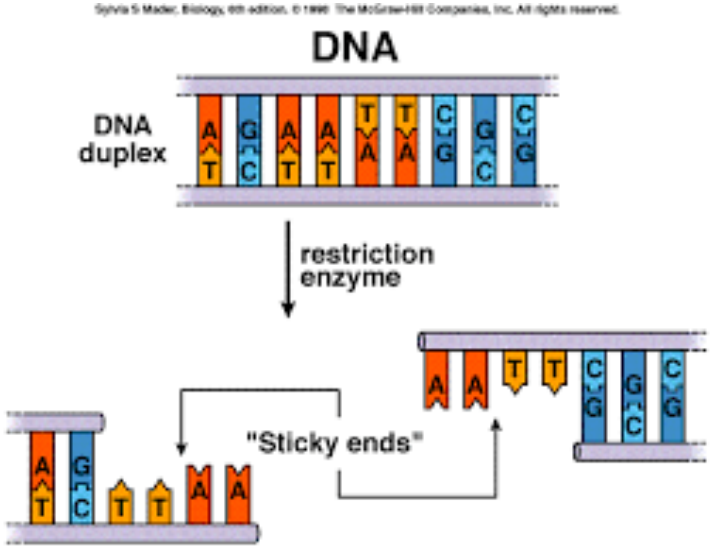
Seismic Signals



- Time Registration Problem in time domain
- Work in frequency domain

3. DNA Restriction Fragment Assembly

- Human Genome Project: Chromosome 19
- A **restriction** fragment is a **DNA** fragment resulting from the cutting of a **DNA** strand by a **restriction** enzyme



DNA Cutting

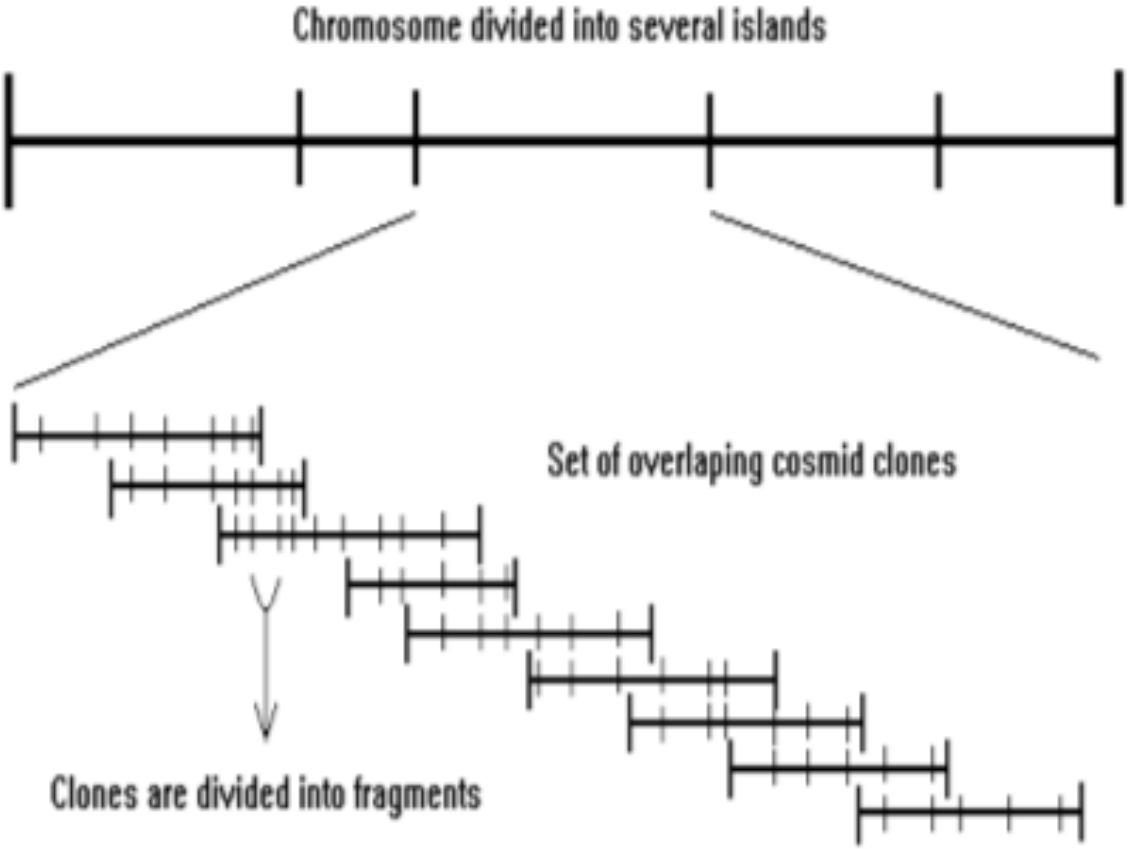


Figure 1: Pictorial view of DNA cutting.

4. Groundwater Remediation

- LLNL Grounds (1 sq mile area) was polluted with hydrocarbon spills during WW II
- The groundwater is flowing toward the city of Livermore and pumped there for consumption
- We used a GA to design a strategy of locating pumping and recharge wells (constraints: Buildings of LLNL where you cannot dig wells)

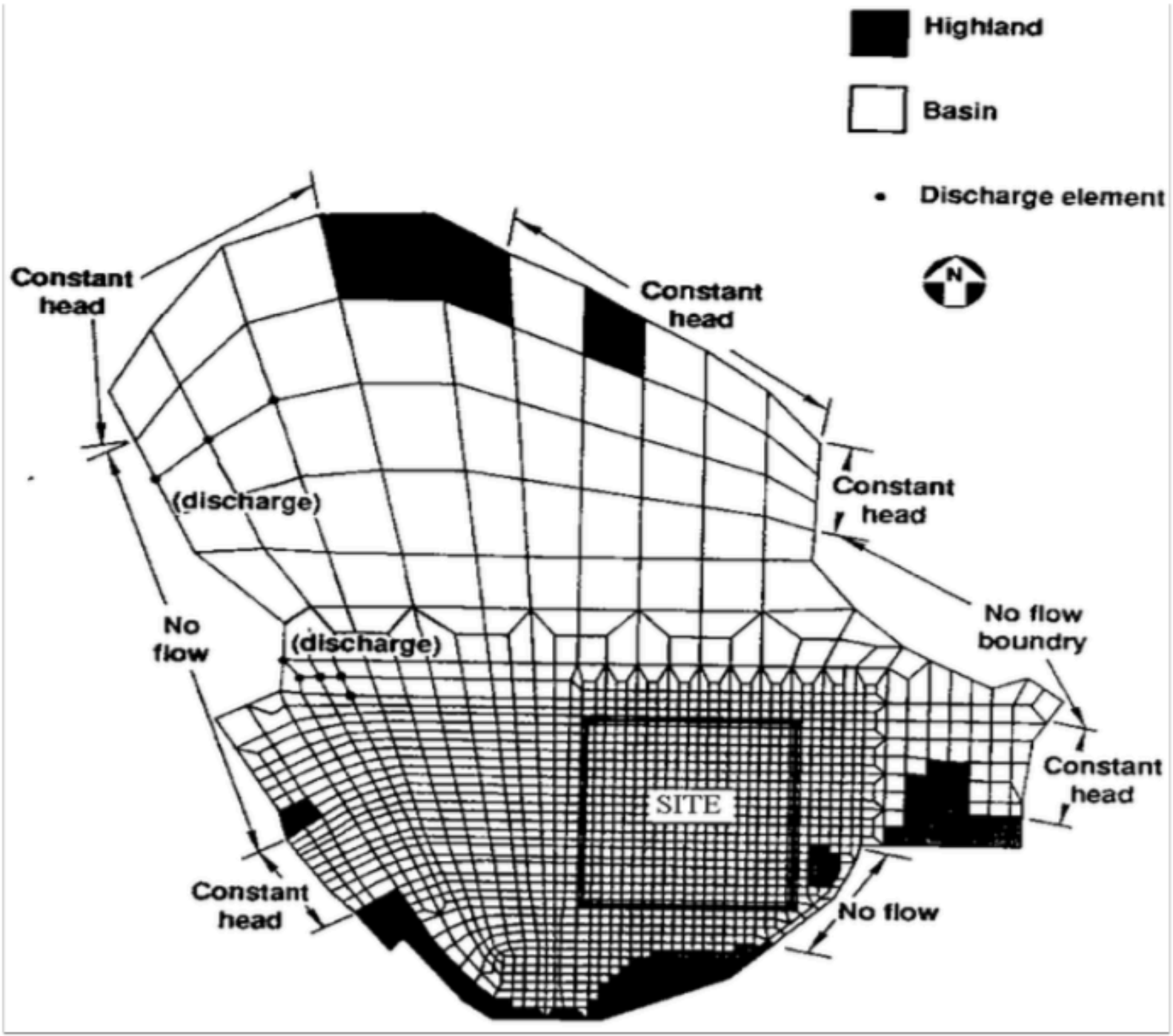


Figure 1: SUTRA nodes and elements in mesh.

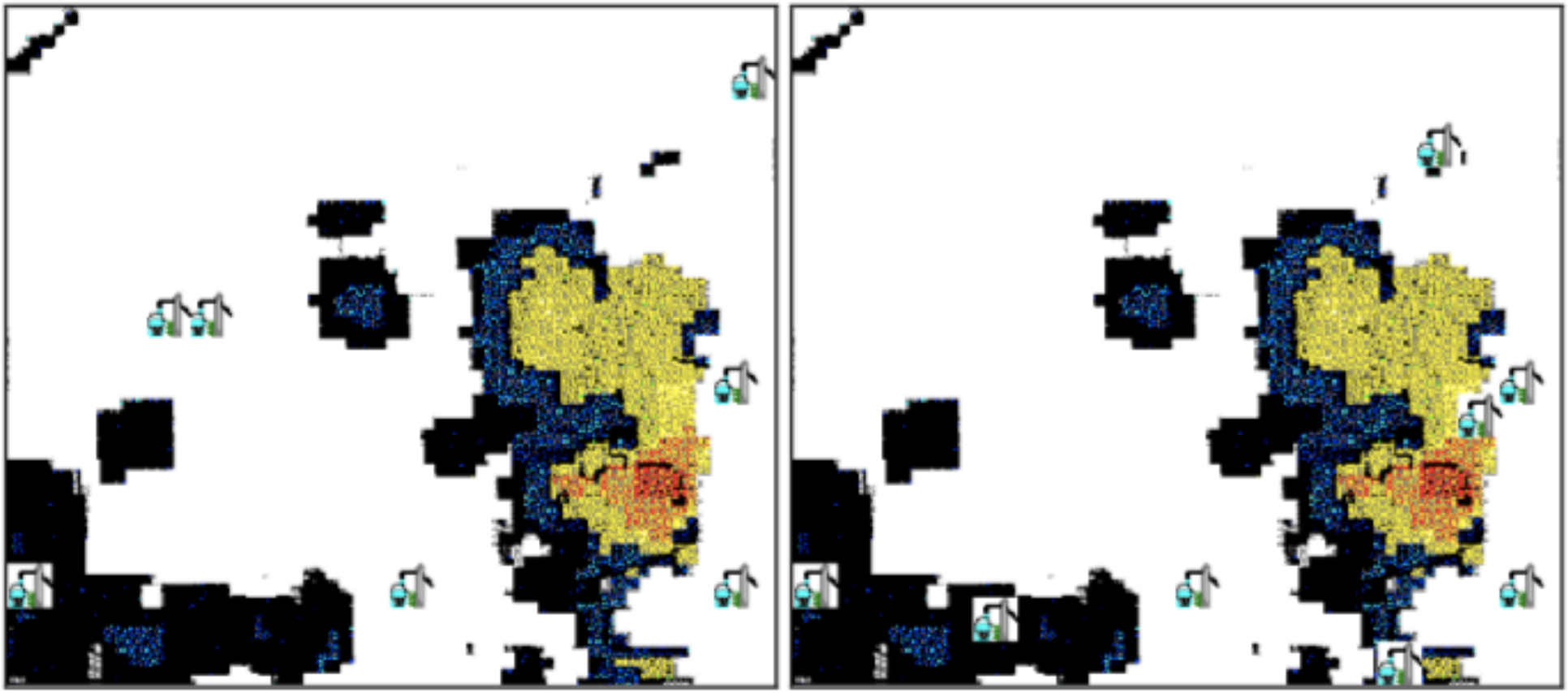
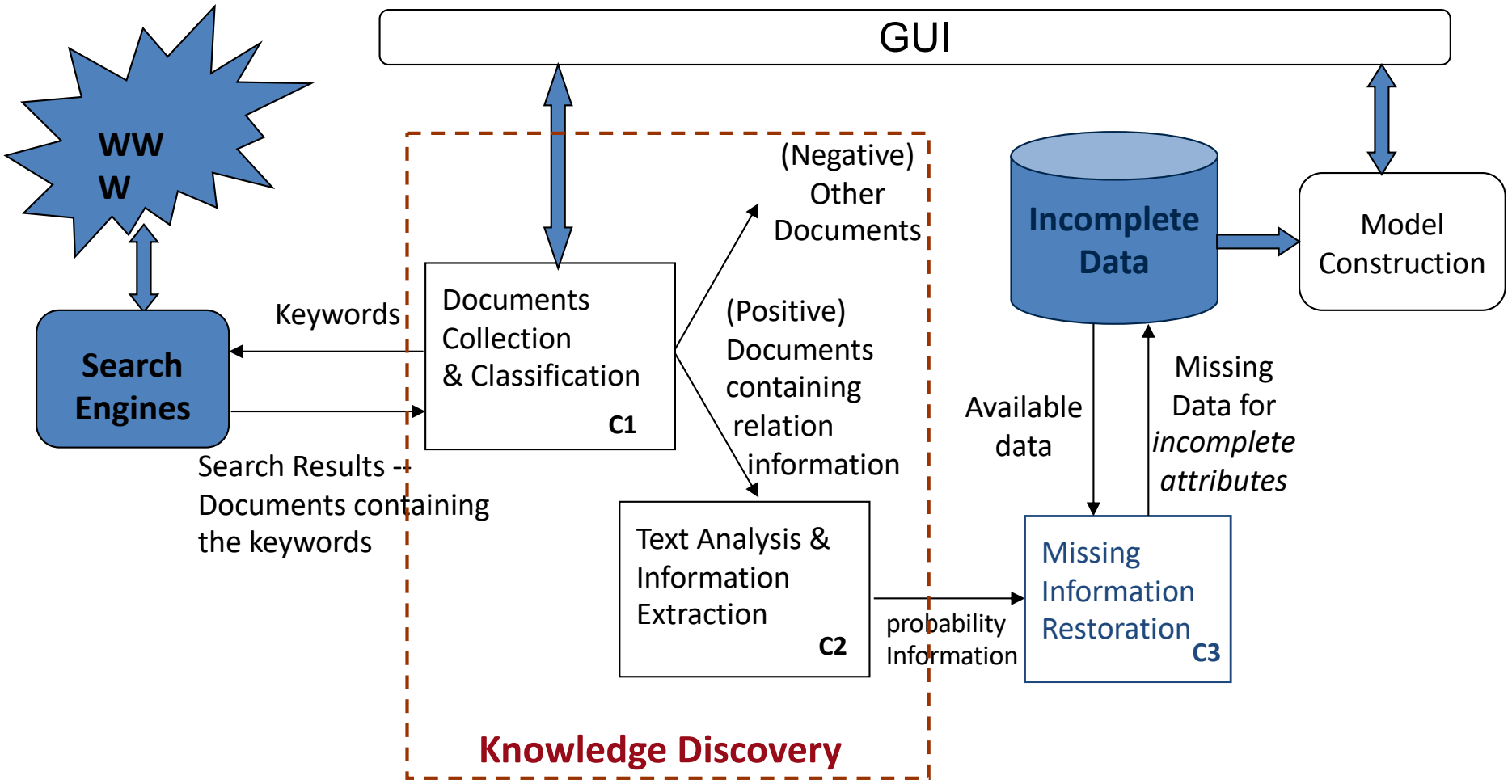


Figure 4: Well configurations for the fourth (left) and fifth (right) solutions in Table 1.

5. Knowledge Discovery and Inverse Problems

- Are there Weapons of Mass Destruction (WMD) in Iraq
- We used Bayesian Networks
- Restoring missing information using Knowledge discovery instead of imputing them via Expectation Maximization

Our Knowledge Discovery Approach



6. Intrusion Detection Using Text Processing

- Arranged “system calls” during a session as a text document and used document classification techniques to identify intrusions (outliers)

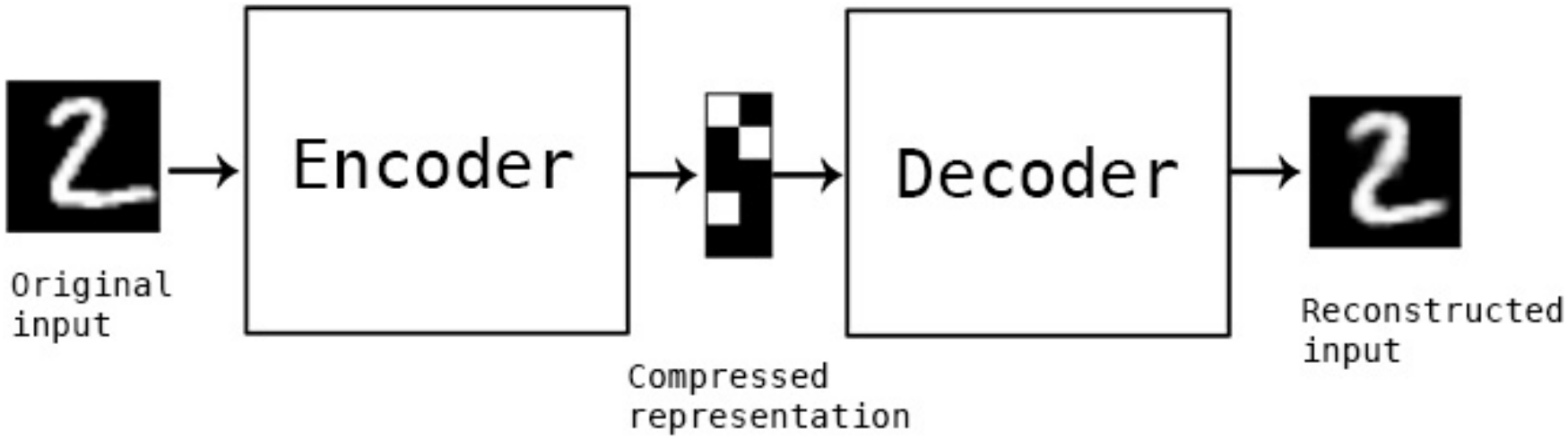
7. Autoencoders for Fraud Detection

- This project was done by an Amador High School student (11th grade) as an entry to a programming competition

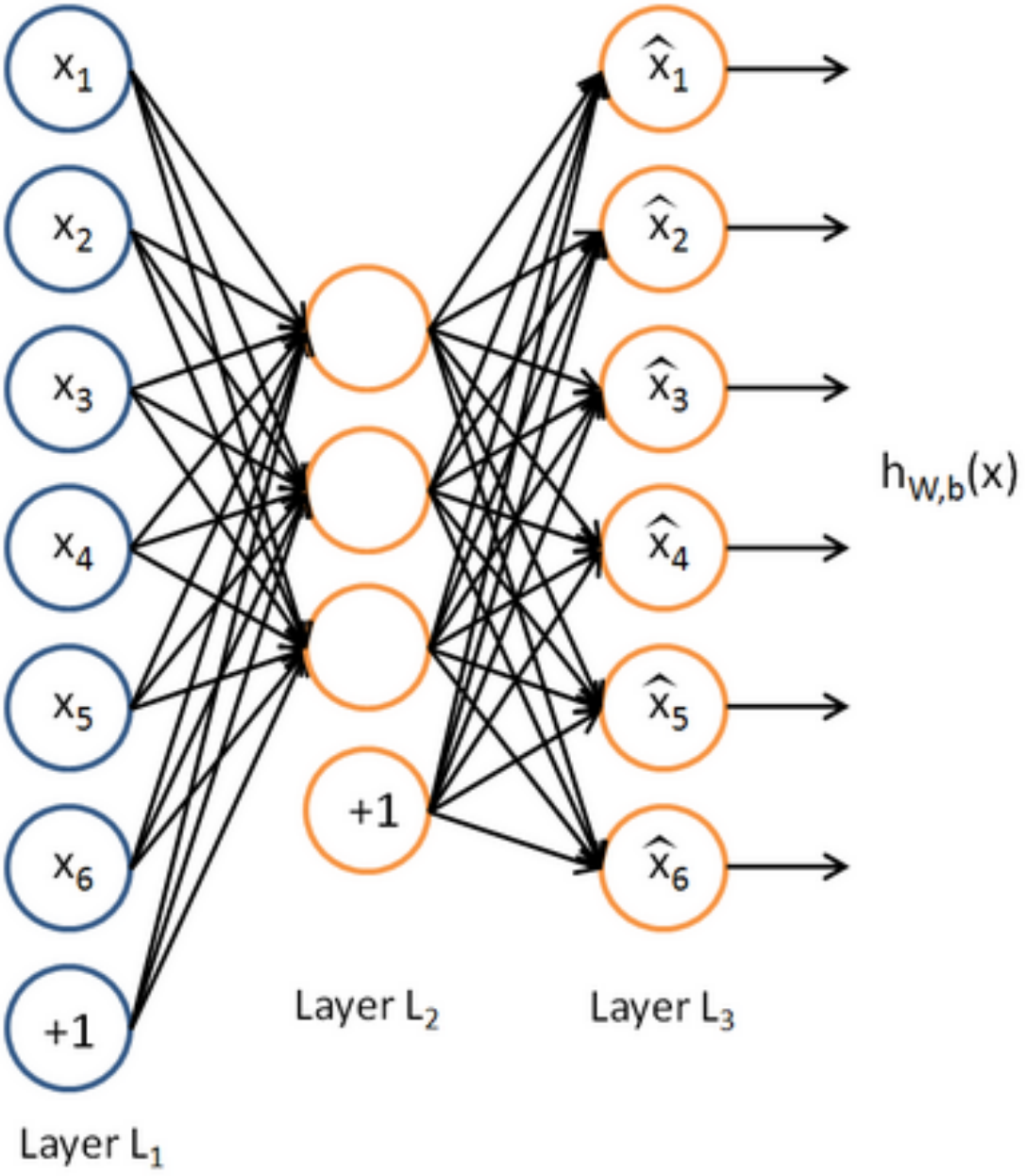
Auto-encoder

- Autoencoder is an unsupervised machine learning method
- There are times you are interested in the underlying structure of data
- Once you understand the structure, you can apply labels
- Autoencoders are an important family of neural nets that are well suited to this task

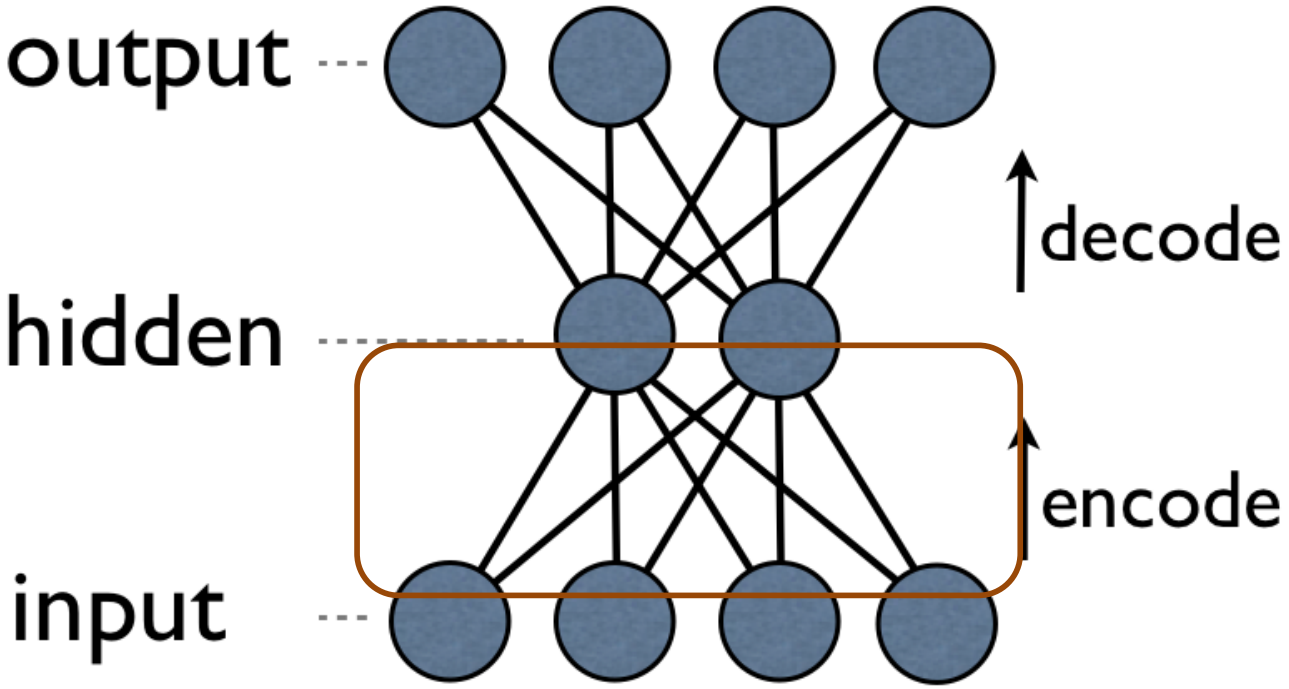
The Idea


Encoder
Decoder
Original input
Compressed representation
Reconstructed input

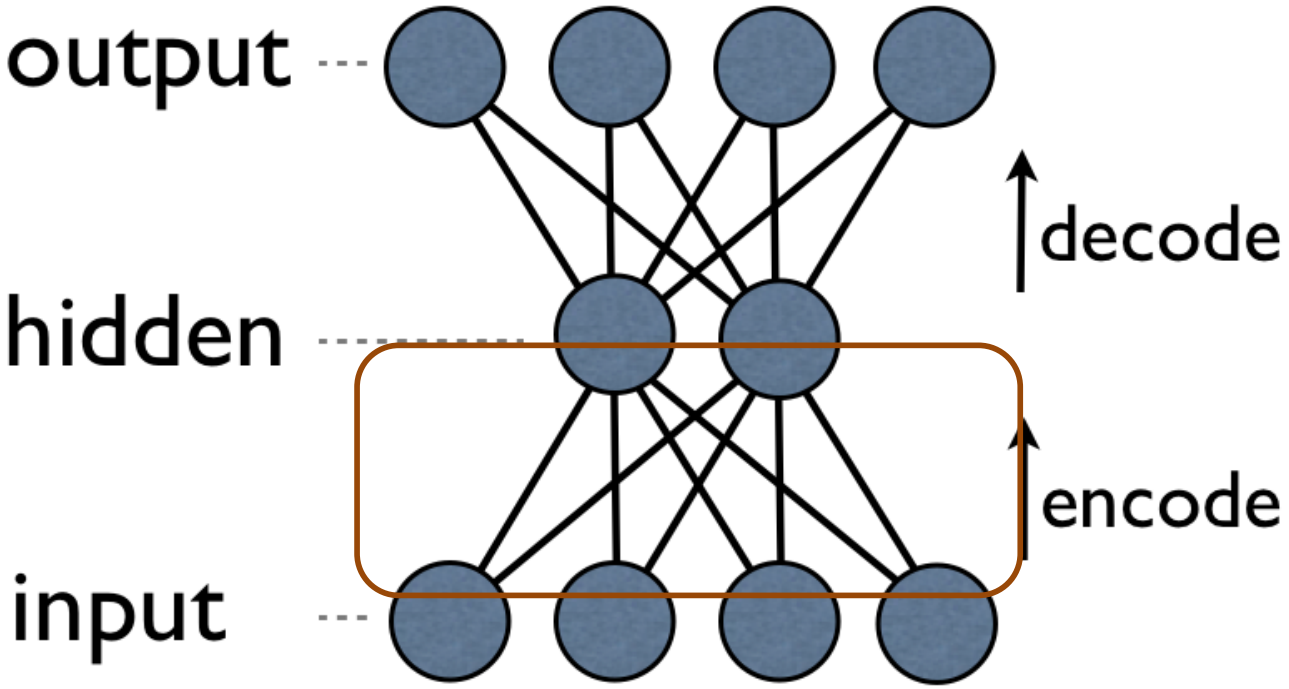
Architecture of Auto-encoder



an auto-encoder is trained, with an absolutely standard weight-adjustment algorithm to reproduce the input



an auto-encoder is trained, with an absolutely standard weight-adjustment algorithm to reproduce the input



By making this happen with (many) fewer units than the inputs, this forces the 'hidden layer' units to become good feature detectors

Embracing Emerging Technologies

IBM’s Watson

- Consider what it would be like to have a system that could look at massive volumes of text, apply thousands of rules that link together questions and possible answers, and build up evidence for believing an idea. That’s Watson.

- Watson is the only software system to have its global debut broadcast on national television. Going head-to-head against acclaimed champions Ken Jennings and Brad Rutner, Watson demonstrated that it could not only be smarter than people, it could be smarter than people in an arena that seemed to define smartness. Even more important, it was smarter using techniques that seemed uncannily similar to the way our own minds work.

Deep Learning

- ✓ Imagine starting with an incredibly detailed set of features that makes no sense to you and having a system recognize and categorize things in a way that does make sense. That's deep learning.

Predictive Analytics

- ✓ Envision being able to anticipate, and therefore avoid, problems before they arise. That's predictive analytics.